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THE RELATIVE IMPORTANCE OF HUNTING RESTRICTIONS AND LAND USE IN MAINTAINING WILDLIFE POPULATIONS IN OHIO

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One of the traditional methods of managing our wildlife resources has been to restrict their use by adoption of regulations designed for that purpose. The taking of game, in some places at least, has been regulated since Biblical times (Deuteronomy 22:6). In our own country the game harvest was at first regulated by certain tribal customs which were in effect before the coming of white settlers. As settlement of the country progressed and wildlife appeared to decline in abundance the simple tribal taboos on the taking of wildlife during the reproductive season gave way to more complex restrictions. These we now speak of as the game laws which govern hunting by some 6,000,000 to 10,000,000 persons in the United States each year.

Presumably the complexity and severity of the regulations adopted provide a rough measurement of wildlife abundance in relation to hunting pressure. If this is true it follows that a study of the game laws should provide an index to past and present wildlife abundance and a measure of the effectiveness of regulations in perpetuating the crop. It is the purpose of this paper to set forth the results of such a study in Ohio.

Interest in the study stemmed from several sources as did material upon which it is based. A chapter by Dr. Paul B. Sears (11) in "The History of Ohio" first aroused the writer's interest in the subject. This interest was further heightened by a challenge from Dr. T. H. Langlois (6) to game administrators to demonstrate that the expenditure of large sums of money for law enforcement by the states was productive of results in terms of higher fish and game populations.

Two excellent sources of useful historical data in this field were available for reference. These include a History of Conservation Restrictions in Ohio, by the late Judge C. M. Finfrock (3) and a Summary of Ohio Game Regulations from 1890 to 1930 which was prepared by Mr. E. L. Wickliff, (12). Neither summary has been prepared for publication. Judge Finfrock, authorized the writer to freely use his data (4) and loaned a typewritten copy of the material for this purpose. Mr. Wickliff kindly permitted the writer to use his material for reference.

The principal sources of data presented in this paper in addition to the above references are the Laws of the Northwest Territory which governed the use of wild-

[1]The writer wishes to express appreciation for assistance in the preparation of this paper to Mr. E. L. Wickliff, who helped materially in furnishing records of Ohio game laws and in suggesting sources of information used in compilation of this report. He wishes also to acknowledge the assistance of his colleagues in the Ohio Wildlife Research Unit, Dr. D. L. Leedy and Mr. E. E. Good, who read the manuscript and offered suggestions for its improvement. Particular thanks are due his wife, Christine K. Dambach, for the laborious task she performed in checking dates and length of open seasons presented in Chart 1.

life in Ohio prior to its statehood, the Laws of Ohio passed by the State Legislature, the Orders of the Ohio Conservation Council and later the orders of the Ohio Conservation Commission. The Annual Summary of Fish and Game Laws published by the United State Fish and Wildlife Service was also consulted.

Data from the above sources and from U. S. Census Reports (1, 2) were used in the compilation of a Chronological Record of hunting and trapping restrictions in Ohio (Chart I and Figs. 1, 2, 3, 4), and land use changes which effect wildlife populations (Figs. 5, 6). Although the regulations are believed to be essentially correct as presented, some errors may have occurred in interpreting which of the many laws passed in a single legislative session actually were later enforced.

CHRONOLOGICAL RECORD OF WILDLIFE-USE RESTRICTIONS IN OHIO

Protecting man from wildlife.

Laws regulating the use of Ohio's wildlife resources pre-date its statehood. Before 1800 settlers sought protection of themselves and their property from wild animals by the provision of a bounty to encourage the killing of predatory animals and safeguarded the right of all persons to use fire arms for "killing or destroying any wild animals" (Laws of the Northwest Territory, 1790, 1799). Protecting man and his property from wildlife was the primary objective of nearly all legislation concerning wildlife during the period between 1790 and 1857. Most of the laws passed concerned the payment of bounties to encourage the killing of wolves panthers, hawks, and for one biennium, squirrels. The latter law, promulgated in 1807, made it mandatory that each person subject to payment of a county tax "shall in addition thereto, produce to the clerk of the township in which he may reside, such number of squirrel scalps, as the trustees shall, at their annual meeting apportion, in proportion to their county levies, provided that it does not exceed 100 nor be less than 10" (Ohio Laws, 1807).

A penalty of three cents a scalp for the number not turned in was authorized. Although this law was repealed at the next session of the legislature (Ohio Laws, 1809) it is indicative of the attitude of man toward the fauna of his newly invaded environment. Whether or not he succeeded in subduing wild animals through use of the axe which changed the environment or the use of the gun which the bounty encouraged is an important point to consider in our present efforts to manage wildlife for man's benefit. Several other important points are, however, clear from these early records:

1. Game useful to the early settlers and the resident Indian population was present in sufficient abundance in relation to need that no legal effort was made to conserve the supply.
2. Some species of *forest inhabiting* wildlife were present in such numbers as to destroy mans livestock and crops leading him to seek legislative means of protection. Predatory animals were the chief objective of this action.
3. Game animals and their natural predators were abundant at one and the same time.

Protection of wildlife from man.

Although some bounty laws intended to protect personal property from wildlife damage are still in force, they are now of relatively minor significance compared to laws designed to protect wild animals from destruction by man. The first of the latter laws in Ohio was passed in 1829 to safeguard the fur trade. It provided "that if any person shall, between the first of May and the 15th of October following, kill or destroy any muskrats and be thereof convicted—he shall forfeit and pay one dollar for each muskrat—except—where muskrats are destroying property", (Ohio Laws, 1829.) This law was later amended to further protect the fur trade in the Lake Erie counties by extending the closed season and including also the beaver, marten, mink and otter as species to be protected (Ohio Laws, 1833, 1840, 1843).

Apparently little concern was felt for other fur bearing or game species until about 1857. In that year closed seasons were established to protect the bob-white quail, deer, dove, ducks, flicker, geese, prairie chicken, rabbit, ruffed grouse, wild turkey and woodcock. Complete protection throughout the year was provided for certain songbirds, namely: sparrow, robin, bluebird, martin, thrush, mocking bird, swallow, redbird and catbird. In the immediately succeeding years addi-

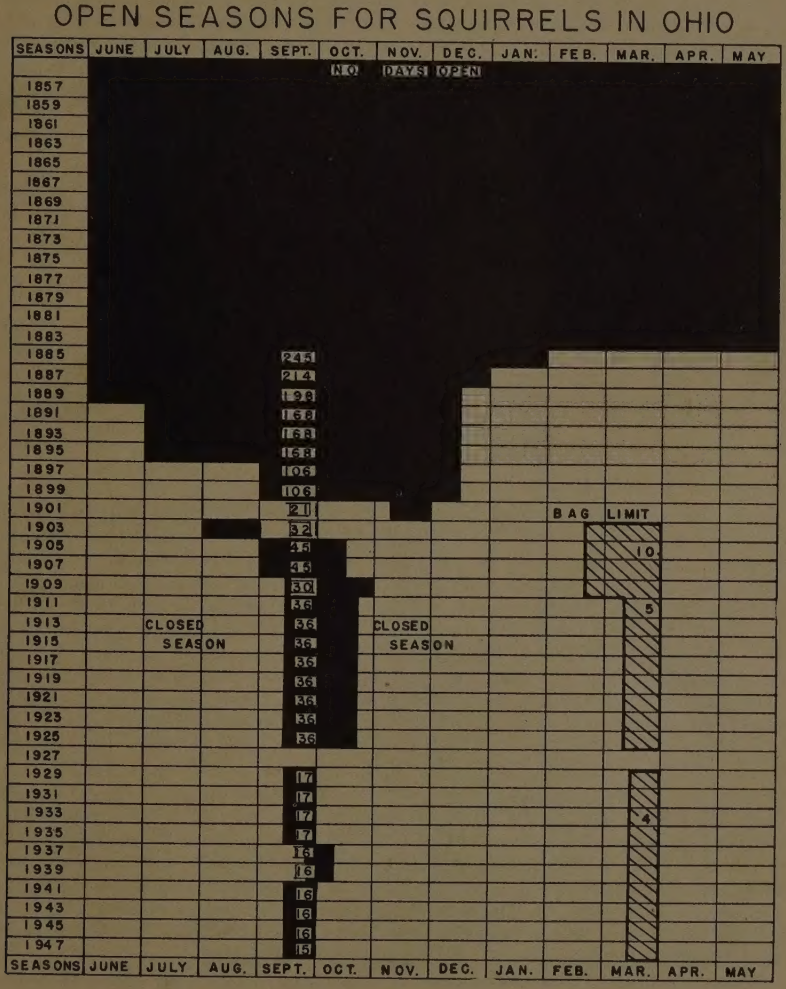

FIG. 1. Open seasons for squirrels in Ohio. Grey and fox squirrels were among the last of Ohio game species to receive the protection of closed seasons. Protection was first given them in 1885 when a 245-day open season was declared. Subsequently the open season was drastically reduced, closed for one year, and augmented by a bag limit which now stands at four per day. This is a marked change from the Ohio law in 1807 which made it mandatory that squirrels be killed.

tional species were given some degree of protection and the closed season was progressively lengthened. (Chart I.)

By 1885 nearly all of our important game and fur bearing species were afforded partial protection and most song and insectivorous birds were completely protected. Providing protection during the breeding season alone was not considered an adequate measure to halt the apparent decline of wildlife in relation to demand. The Legislature early sought other means of coping with the problem. One of these measures was to prohibit all hunting of endangered game species for one or more years in order that they might recover. Hunting of quail, for example, was prohibited in Fulton county for a five year period beginning in 1885. Deer hunting was banned for a four year period beginning in 1896, a ban which subsequently was extended to 1943 when the state had its first legal deer season in nearly fifty years. Similarly, quail and doves were given a rest period in 1913 but later, apparently because they did not respond to protection they were classed as song birds thus removing them from consideration as game species.

The addition of a bag limit to the complex of wildlife use restrictions in 1902 is indication that the legislators were thinking of an equitable distribution of the game crop as well as safeguarding the species. Bag limits like open seasons however became progressively smaller in succeeding years. They were augmented from time to time by new regulations designed to limit the method by which animals could be taken, to limit the number held in possession, to prohibit the sale of wild animals and still more recently to limit the hours of the day during which they can be taken. A few examples of these measures are the outlawing of the use of ferrets in hunting rabbits, the three shell limit in hunting waterfowl, prohibiting baiting and use of live decoys in waterfowl hunting, delaying hunting on the opening day of the season until noon and the most recent restriction in Ohio of limiting hunting to the hours between 9:00 a.m. and 4:00 p.m..

Development of public interest in wildlife conservation.

More than 85 years elapsed between the time the first laws affecting wildlife were passed in the state and the appointment of an official body to enforce them. During this interim game laws were enforced, if at all, by local officials. One of the earliest enforcement problems dealt with the rights of landowners to hunt without restriction upon their own property. This right was upheld by law for rabbits and doves up to 1865 and for rabbits only until 1874. Although the right to regulate the use of resident wildlife on all lands is now clearly vested in the state (Ohio Laws, 1919) there is still evidence of non-compliance particularly in remote areas.

The first official body in the state to deal with these and other wildlife conservation matters was a three-man Ohio Fish Commission created by an act of the Legislature in 1873. Its duties were largely concerned with investigation and recommendation. A new five-member commission, called the Commission of Fish and Game, was appointed in 1886. The law establishing the new commission provided among other things that: the Governor by and with the consent of the Senate shall appoint five Commissioners of Fish and Game, of whom no more than three shall belong to the same political party, one for one, one for two, one for three years and so on and who shall be subject to removal at the governor's pleasure. It further provided for the appointment of fish and game wardens to enforce the fish and game laws. These wardens were to be appointed from the political party polling the most votes in the previous gubernatorial election.

New commissions were subsequently appointed under the terms of this act until 1913 when the Legislature replaced it with a Fish and Game Division within the State Board of Agriculture. A seven-member Advisory Board was appointed in 1923 to assist the new Division in developing a policy and a program of action. Another major change took place in 1929 when the Legislature abolished the Division of Fish and Game and created a Division of Conservation headed by a

commissioner who was appointed by the State Director of Agriculture. A council of 8 members appointed by the Governor for four year terms was established to guide the program of the new Division. Ten years later the present Division of Conservation and Natural Resources was established by legislative action. A nine-member commission appointed by the Governor employs a commissioner who is charged with responsibility for carrying out the program and policies deter-

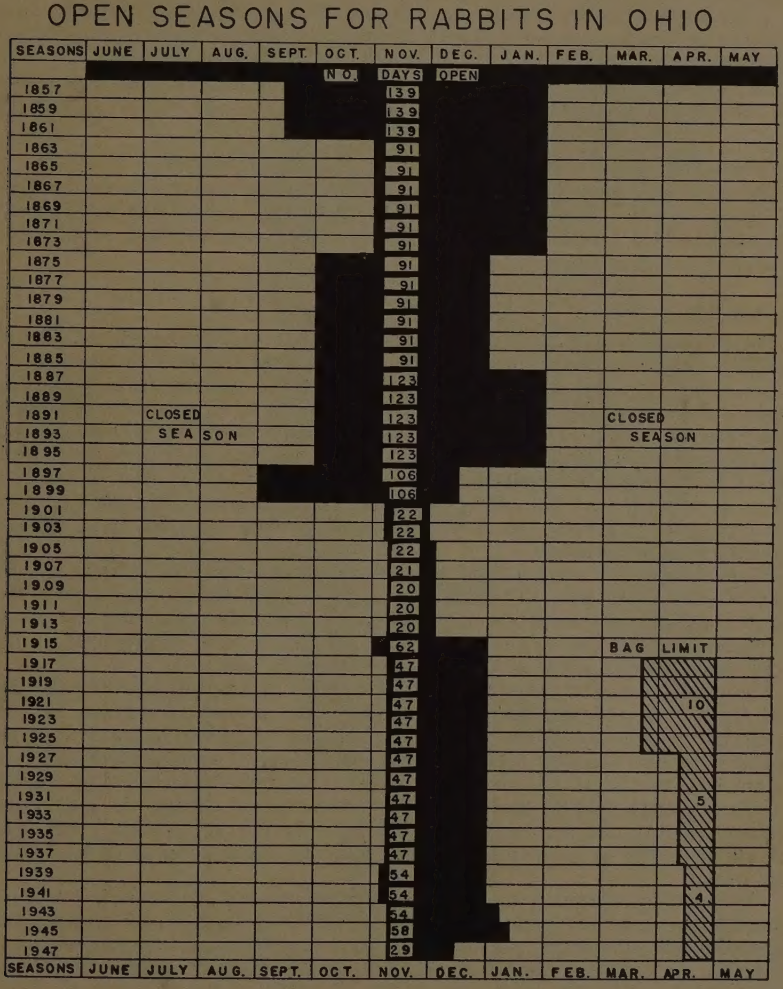

FIG. 2. Open seasons for rabbits in Ohio. Cottontails have been protected by closed seasons in Ohio since 1857 and by a bag limit since 1917. It is of especial interest to note that the shortest seasons in the State's history occurred at the turn of the century when urban population was greatly increasing and when woodland area on farms was rapidly being depleted.

mined by the commission. The commission is bi-partisan, composing not more than four members of the same political party. The ninth member, the State Director of Agriculture, serves on the commission but has no vote in matters concerning personnel. Terms of the commission members who serve for eight years are staggered so that it is unlikely that any one governor may appoint a majority of its members.

The over-all objective of these changes has been to broaden the responsibilities of the state with respect to its wildlife resources and to make more effective its law enforcement efforts. Both the Conservation Commission and the former Conservation Council were vested with authority to issue and enforce fish and game regulations (Section 1390, General Code of Ohio). The present Commission thus is directly charged with responsibility for providing that the wildlife crop is equitably harvested and that it is perpetuated.

Effectiveness of Game Laws in Perpetuating Wildlife Resources.

The majority of the personnel hired by the various conservation commissions in Ohio as in other states have been used to enforce regulations passed by the Legislature or by Commission Order. The effectiveness of these regulations is considered in the sections to follow:

Forest Wildlife

The principal forest game species in Ohio were the Virginia white-tailed deer (*Odocoileus virginianus virginianus*), the grey squirrel (*Sciurus carolinensis*), the eastern ruffed grouse (*Bonasa u. umbellus*) and the eastern turkey (*Meleagris gallopavo silvestris*). All of these species were reputed to have been very abundant in the State at one time. Except for the grey squirrel they have all been protected by progressively longer closed seasons since 1857 and in more recent years by bag limits (Chart I). It is significant that both the white-tailed deer and the wild turkey were extirpated from the State despite the protection afforded them and that extirpation resulted 9 to 15 years after they were supposed to be protected by complete closed seasons.

Squirrels which in 1807 had to be killed to avoid a tax penalty were not given any protection until 1885. The precipitous rate at which the open season was shortened thereafter and the enforcement of a strict bag limit apparently did not halt the decline of these animals (Fig. 1). Similar trends were experienced for other forest game species such as the raccoon (*Procyon lotor*).

The rapid decline of forest wildlife species was in proportion to the decline in total forest area and woodland area per farm and inverse to the rise of human population in the state. (Figs. 5 and 6.) The rate of decline however apparently slackened or was arrested before the rise of the heavy gun-pressure which now characterizes our hunting seasons. This is evident from the fact that open seasons on present forest wildlife have been somewhat relaxed during the past decade. Two species, for example, the ruffed grouse and the now reintroduced white-tailed deer are increasing in number and a third, squirrels, are apparently at least holding their own.

The most logical explanation for this phenomenon is to be found in the amount of land in the state abandoned, in recent years, for agricultural use and in various stages of forest succession. Leedy (8), in a companion paper has pointed out that during the "first 40 years of the present century the number of farms in the southeastern third of Ohio dropped from 86,759 to 73,073 and the land in farms from 8,148,134 to 6,949,919 acres". Most of this land is at present in a stage of plant succession more favorable to deer than the original unbroken forest. As the succession moves on to more mature forest conditions for grouse and squirrels should improve.

Fur bearing animals.

Interest in the welfare of fur bearing animals, other than the beaver, marten, mink, muskrat and otter was not reflected in hunting restrictions until after 1900. Restrictions on the forest inhabiting raccoon as on the squirrel rapidly became more severe soon after their introduction while those on the more adaptable foxes fluctuated greatly from season to season in probable response to competitive lobbying by farm and fox hunter interests. Both grey and red foxes markedly

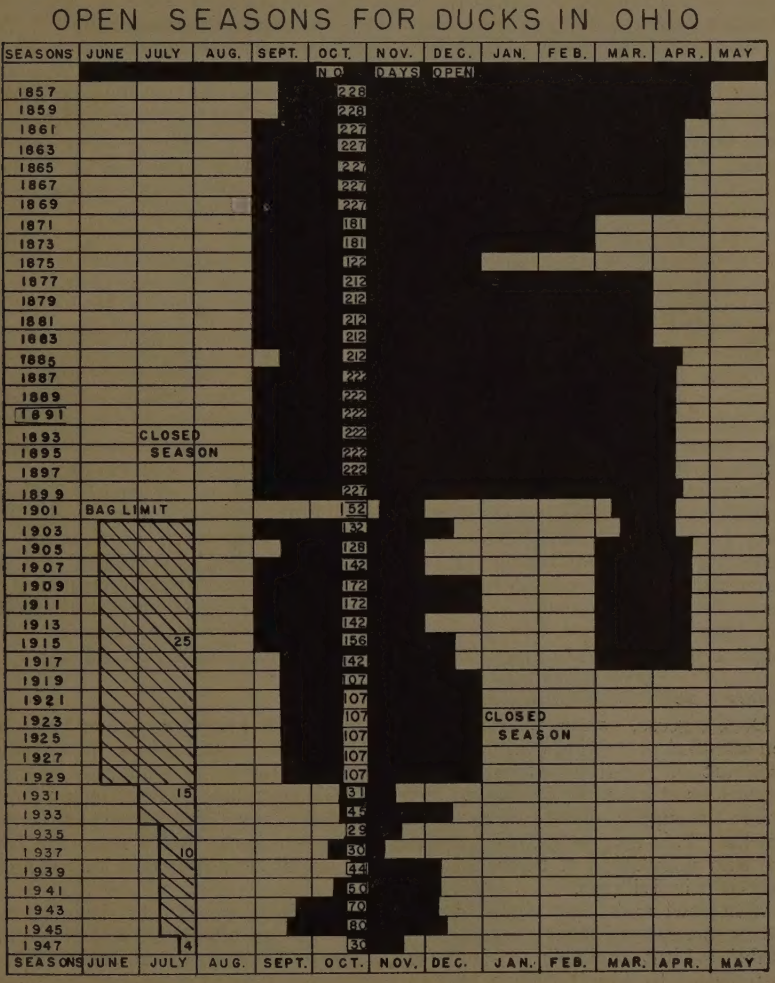

FIG. 3. Open seasons for ducks in Ohio. Restrictions on waterfowl hunting have varied greatly since they were first established in 1857. The lowest ebb in the waterfowl population occurred during the early 1930's when the season was reduced to 30 days. It was subsequently raised in response to improved reproductive conditions despite constantly rising gun pressure. The season has again been drastically lowered because of poor reproduction and a great postwar increase in hunting pressure.

increased in recent years despite the removal of the closed season protecting them and the enactment of a bounty law in 1945 to encourage their slaughter. They have decreased sharply however since 1946.

The trend of restrictions applied to muskrats is a remarkable indicator of population changes in response to environmental alterations. (Fig. 4). This was the first animal to be afforded the protection of a closed season in the state. In some counties where it is now wild-trapped on a commercial scale (Huron, Lucas, Ottawa and Sandusky counties) the trapping season was reduced to but 60 days in 1840 or approximately one-half the present open season in the same area. (Chart I). For the entire state the open season on these animals is now about 20 days longer than it was during the period between 1867 and 1911. The annual fur harvest in the state indicates that many more muskrats are trapped now by more trappers than at any previous time. It also indicates that the number of muskrats pelted fluctuates from year to year largely in response to economic inducement, favorableness of the trapping season and natural factors not now fully understood.

Explanation for the general increase in the annual muskrat crop during modern times can best be found in a great increase of habitable environment. Impounded water in Ohio which has resulted from flood control, water storage and recreational developments is now more than 1,000 percent greater than at the time of settlement. Muskrats occupy most if not all of these large impounded areas. They have also benefited greatly from the thousands of miles of open drainage ditches in the level agricultural regions of the state. These ditches provide both good sites for muskrats homes and an abundance of superior foods such as corn, soybeans and leguminous forage plants which grow in the nearby crop fields. More than 100 muskrats per mile of drainage ditch have been harvested on an annual basis in some of the more productive areas of the state. Drainage ditches which now exceed natural streams in the state in total length are much more productive of muskrats per unit of area or length than virgin streams that flowed through wooded areas.

Fluctuations in the number of other fur bearers is not so readily explained. There is evidence however that some species, notably beaver and otter became or nearly became extirpated despite early legal action for their protection. It is interesting to note that beaver are becoming reestablished in a number of eastern Ohio counties where considerable land has been retired from agricultural use. These colonies, it should also be noted, probably could not persist without protection from disturbance afforded by local game protectors. The latter thus are able to protect brood stock established through favorable environmental changes.

Migratory wildlife.

Ducks, geese, swans, woodcock, doves and other migratory game birds have been afforded protection during their nesting seasons in Ohio since 1857. (Fig. 3 and Chart I). During this period the restrictions in effect have undergone extreme fluctuations at irregular intervals. It is probable that these changes reflect fluctuations in the supply of waterfowl due to environmental conditions such as recurrent drouths. This is known to be the case during the early 1930's when the North American population of these birds reached an all time recorded low of around 23,000,000 individuals.

Waterfowl and most shore birds are particularly subject to decimation by hunting because of their gregarious behavior during migration and the limited suitable habitat available to them for resting or feeding during this period. It is interesting to note, however, that further restrictions on the waterfowl hunting season in 1946 were made in response to a drop in the duck population that occurred while hunting pressure was at its lowest ebb in recent years due to war conditions. Despite the shortened open season and reduced bag limit the population dropped still farther before 1947, resulting in an open season reduced to but 30 days and a bag limit of 4.

Woodcock are more generally distributed and subject to far less gun pressure during the hunting season than are waterfowl. According to Leedy (7) only 3.6 percent of Ohio hunters pursued this bird during the 1947 season as compared to 9.1 percent who hunted ducks. The population of these birds, however, has apparently continued to decline despite progressively tightened restrictions on

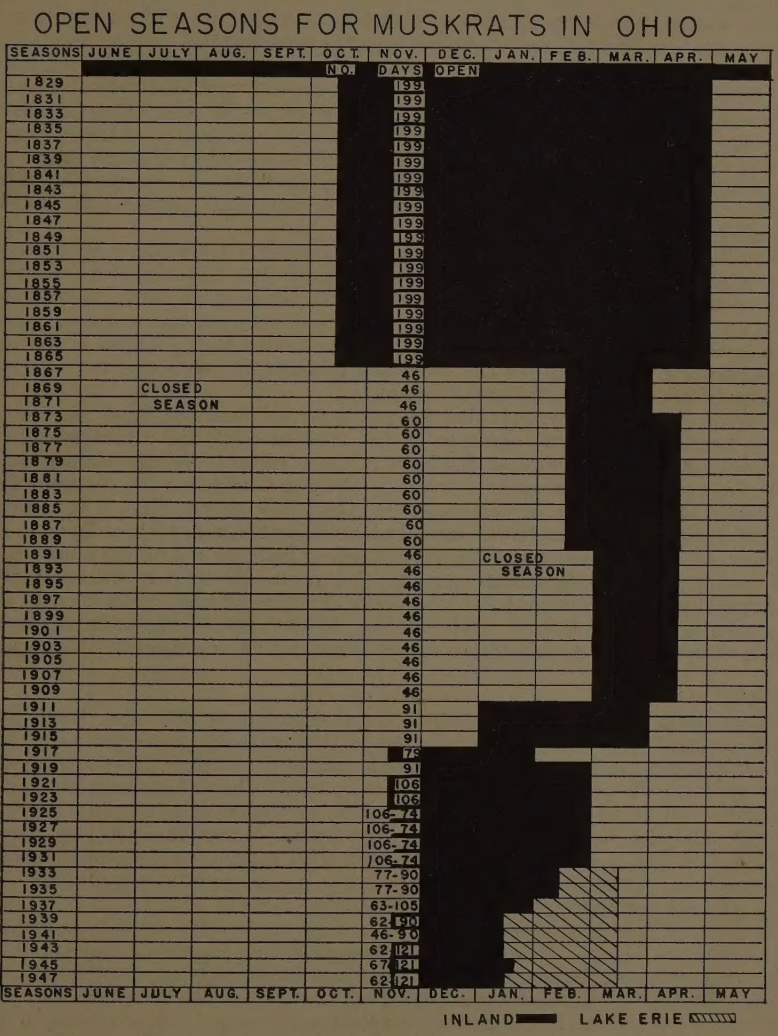

FIG. 4. Open season for muskrats in Ohio. The muskrat has been protected in Ohio for nearly 120 years. We now enjoy a longer trapping season with more pelts being taken annually than was true during the period between 1867 and 1915. This change is probably due to a great increase in habitable muskrat range resulting from improvements for agricultural use of the land such as open drainage ditches and water impoundments for flood control, water storage and recreational purposes.

their use. A similar trend characterizes the population of other shore birds (Chart I). Most of these had reached such low population levels by 1931 that they were then given completely closed seasons. They have not since recovered sufficiently to justify even a very limited open season.

Many words have already been written decrying the wanton slaughter of passenger pigeons in Ohio and elsewhere by market hunters. It is generally believed that such hunting led to their extinction in 1919. It is not so well known, however, that in Ohio at least these birds were protected from market hunting by a law passed in 1876 which made it unlawful to "take or destroy wild pigeons in roosting places, or to discharge firearms within one-half mile of same". This law was further strengthened in 1886 by a measure which forbid "disturbing of pigeons, their eggs or nestlings on their nesting grounds or roostings". Mass slaughter of these birds thus was made illegal more than 25 years before the last record of a bird being killed in the state and more than 40 years before the species passed into oblivion. Restrictions thus may have delayed their final demise but certainly did not prevent it.

The history of most vanishing species in this country reads like a sequel to the story of the passenger pigeon. Nearly all of them were afforded some degree of legal protection when their numbers began to diminish greatly. Fortunately, the extinction of some species has apparently been temporarily, at least, averted (trumpeter swan, whooping crane, ivory billed woodpecker). Those which have recovered have done so under the combined stimulus of protection from hunting and provision of their needed environment.

Recovery of the American elk, the pronghorned antelope, and the colonial nesting birds like the snowy egret, wood ibis, Florida crane and others are stirring examples. It would be well, in the light of these facts, to temper condemnation of the hunter as the decimator of formerly abundant wildlife with the knowledge that much of the wildlife he destroyed could not now survive due to agricultural and industrial progress, except in special preserves or refuges. These facts do not, however, in any manner lessen the importance of hunting restriction enforcement as a tool in perpetuating wildlife species. We need only refer to the recovery of the fur seal industry following the international treaty for their protection in 1911 for evidence that protection from hunting beyond the harvestable surplus is necessary even if other suitable environmental factors are favorable.

Resident Farm Game.

Farm game is probably considerably more abundant in Ohio now than it was 150 years ago. The two principal species in this catagory, at present, cottontail rabbits and ringnecked pheasants, provide millions of hours of recreation and millions of pounds of meat to Ohio hunters annually (9). That cottontails have long been held in high esteem by Ohio hunters is evident from the fact that they were afforded the protection of a fairly long closed season (225 days) as early as 1857 (Fig. 2) and subsequently were favored with special restrictions to enhance their welfare. These included prohibiting the use of ferrets, introduction of a bag limit, and prohibiting the sale of legally taken rabbits.

Changes in length of the open season on Ohio cottontails exhibit a somewhat cyclic pattern (Fig. 2). Whether these changes reflect population variations due to hunting pressure, disease or adverse climatic conditions can only be surmised at the present time. It is evident however that whatever the cause cottontail populations have so improved that we have, in recent years, enjoyed a longer open season on them than was permitted half a century ago. The increase in the length of the open season, it should be noted, came at a time when hunting pressure was rising in response to social changes and has been sustained through at least two decades of intense gun pressure. It may be argued that the lengthened open season was made possible through introduction of a bag limit in 1902. Although this

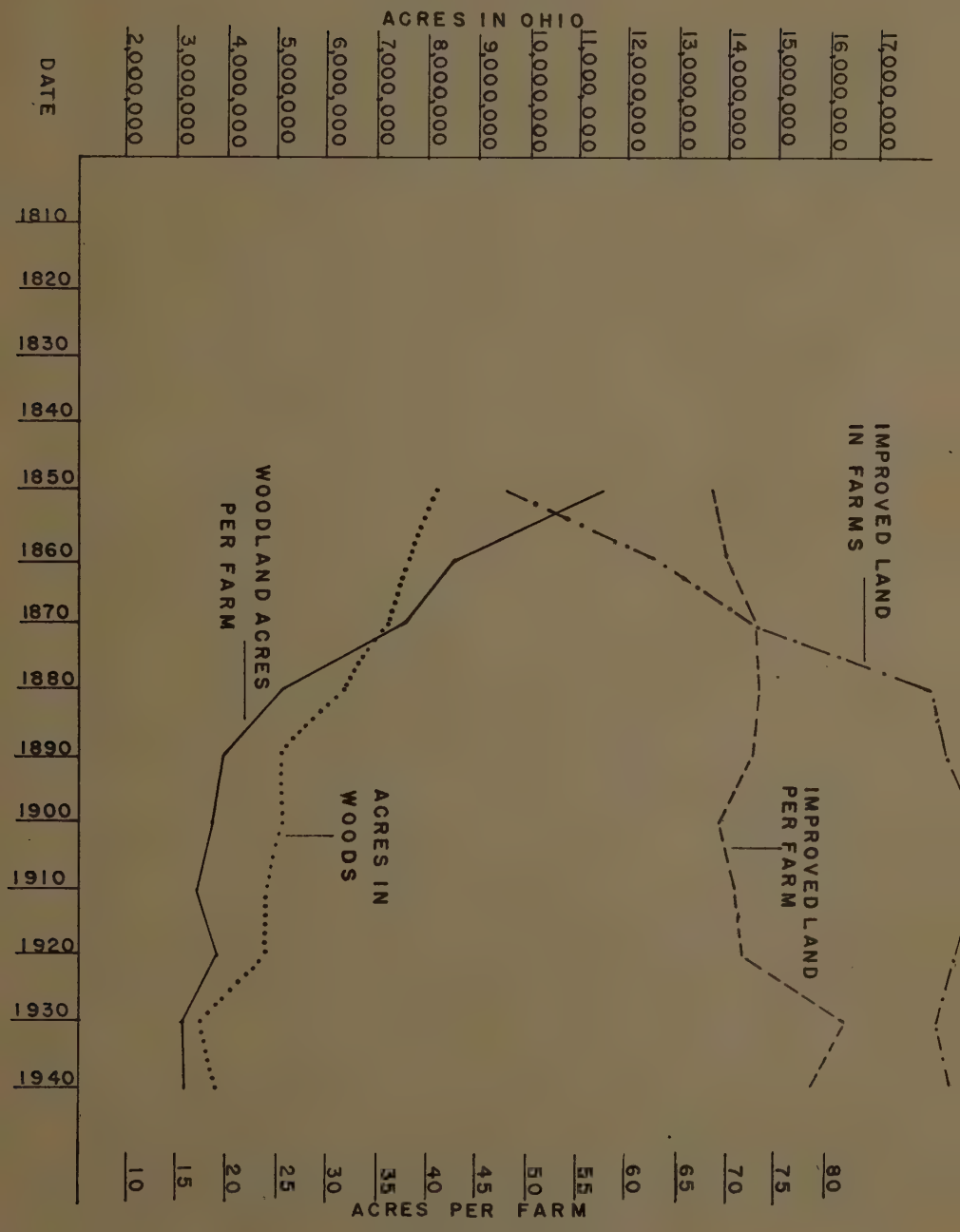

FIG. 5. Changes in Ohio and use.

may be a contributing factor it appears more logical to the writer that the change is due to land use practices such as the growing of forage crops on once forested land.

Ringnecked pheasants, although not introduced successfully into the state until 1896 (5), have also responded well to agricultural use of the land. They too greatly increased in number in the face of rising gun pressure and it is believed for the same reason offered for cottontails.

Our other exotic game bird, the European or popularly called Hungarian partridge has had a less successful history than the pheasant. It has declined in the state to such a low ebb that it has been given complete protection. It is very doubtful however that hunting had much to do with the decline of this bird which is a notoriously difficult target for even the experienced hunter. The European partridge, like the ground nesting cottontail rabbit, ring-necked pheasant and bob-white quail suffered from unfavorable reproductive conditions during the peak nesting period of several recent years.

Of special interest is the fact that the sharp decline of these three species occurred at a time when hunting pressure was at a low ebb with fewer hunters in the field for less time and with less ammunition to expend than usual, due to war conditions. Now that hunting pressure is at an all time high (Fig. 6) the length of the open season has been drastically curtailed to meet the situation. In the meantime we have been favored by a successful breeding season during which both cottontails and pheasants have remarkably recovered to some where near their pre-war abundance. Field studies indicate that the current increase is largely a function of more successful reproduction than occurred during the unfavorable years previously mentioned.

No discussion of farm game in Ohio would be complete without reference to the bob-white quail which has been the subject of a controversy between sportsmen, farmers and nature lovers since it was protected by a closed season and especially since it was made a song bird in 1917. Although the quail, like the cottontail and pheasant, benefitted from early agricultural use of our once forested land it apparently has not been able to hold its own under the more intensive type of agriculture now practiced—particularly in the northwestern part of the state.

Quail have long been protected in this state by favorable closed seasons and special restrictions (Chart I). Their number, nonetheless declined to such an extent that a closed season seemed to be in order before hunting pressure reached the point that a resident hunting license law was put into effect. There is no evidence that quail have responded to this protection. They still experience drastic population slumps in response to unfavorable climatic conditions such as prolonged periods of deep snow cover. The severe winters of 1935–36 and 1944–45 are good examples. Prior to both of these winters Ohio Quail populations had attained fairly stable levels for a number of years. During the severe weather which followed their numbers dropped to a fraction of their average density. It has been observed by this winter that quail populations in Ohio are about the same as those in neighboring states in comparable range and where hunting is permitted. It has also been observed that their populations fluctate to the same degree when similar weather conditions are experienced.

Land use and social changes in relation to wildlife populations.

One of the most obvious social changes affecting wildlife numbers is the change in density and character of the human population. There were less than a million persons in Ohio when the first law protecting a wild animal was passed. At that time 96 percent of the total population lived on farms. Twenty-eight years later, in 1857, the population had more than doubled and at least one of every six persons was living in a city. It was at this time, with a population density of one person per 12 acres in the state that the Legislature took serious cognizance of the welfare

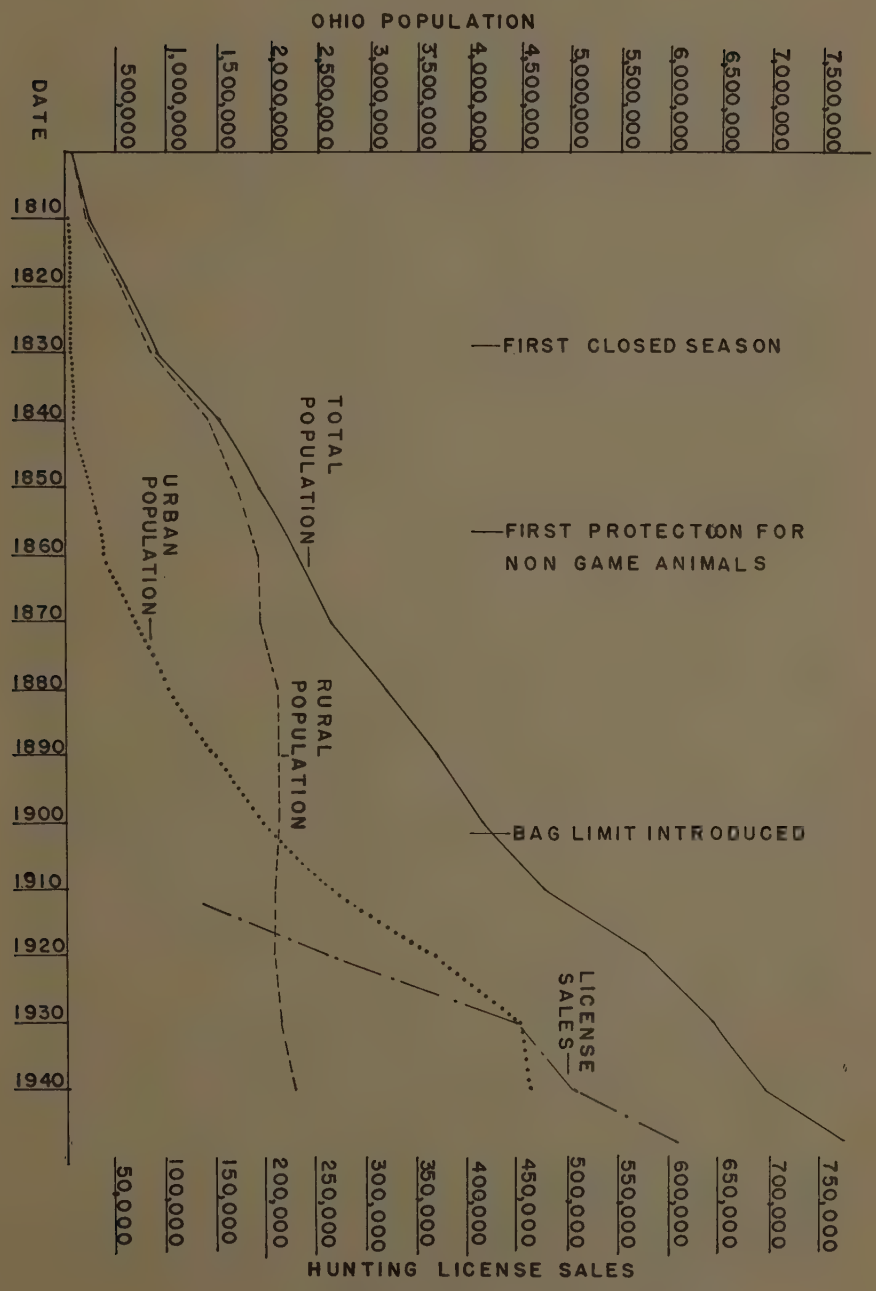

FIG. 6. Ohio population growth, game laws and license sales.

of wildlife and afforded protection to both game and non-game species. Prior to this time there was little inducement for market hunting of wildlife.

The advent of improved transportation facilities following World War I made it possible for many city dwellers to spend an occasional day in the field in pursuit of game thus adding, for the first time, the pressure of city hunters to that exerted by the relatively stable farm population. Growth in the sale of hunting and fishing licenses clearly indicates the rapid trend in this movement. The first resident hunting license law in the state was made effective in 1913. During that year less than 150,000 of the state's nearly 5,000,000 residents, or one in 33, purchased a license to hunt. Hunting license sales since that time have, except for temporary declines due to economic conditions or the recent national emergency, increased at a more rapid rate than population growth. (Fig. 6.)

In recent years hunting license sales have risen to between 600,000 to 700,000 per annum or an average of one license sale per 10 residents or one license per 30 acres of huntable range. These figures do not take into account landowners, farm operators or their children who are permitted to hunt without a license on the land they own or operate. Together these groups probably aggregate nearly a million hunters annually. This represents enormous pressure both on the wildlife and the land that sustains it. Most of this pressure, it should be noted, comes from the urban segment of the population since farm units and farm population have changed little since hunting licenses have been issued. The approximately 250,000 farm units in Ohio today probably sustain three times the hunting population they were subjected to before transportation made it possible for the urban hunter to freely take part in this sport.

Explanation for the rise in the number of persons who seek recreation in the form of hunting may not all be attributed to population growth. Part of it is, of course, due to the desire of men to seek refuge from the complexities of urban life by a few days afield. Opportunity to fulfil this desire has been greatly favored by higher income which has made ownership of transportation facilitites within the means of the average man, shorter working days and short work weeks and the provision of vacations which are part of modern employment practice. Advertising too has surely had an influence on the increasing proportion of our population that hunts or fishes or both. The manufacturers of hunting and fishing equipment have done much to encourage people to participate in these sports through their advertizing in outdoor magazines. This has proved to be a profitable enterprise as these companies and various other businesses profit from the business use of wildlife creates. In Ohio alone expenditures for hunting and fishing have aggregated in excess of $60,000,000 per annum in recent years (9). Even state conservation departments have felt it necessary to advertise their wildlife crop in order to sell more licenses in the interest of securing revenue with which to carry on their work.

We are thus faced with a situation in which social changes are leading to increased hunting pressure without increasing capacity of the land to produce the crop to be harvested. Most of the huntable land in Ohio is in farm ownership where the production of wildlife is at best an incidental and often undesired crop. The public land available for hunting in the state would provide but a fraction of an acre per license holder and is thus of no material consequence, at least at present.

"The ownership of, and title to all wild animals in the State of Ohio, not legally confined or held in private ownership legally acquired,—is in the State, which holds it in trust for the benefit of all the people" (Section 1391, Ohio General Code). Although this law is universally accepted in the United States it has created problems which make the management of wildlife, particularly on private lands, a difficult venture. Under its terms the manufacturer who profits from the sale of hunting equipment may exploit this resource through encouraging hunting with his equipment without doing anything to maintain the resource while the

hunter may use his equipment to harvest game he likewise did nothing to produce. The right of the individual to use wildlife is thus guaranteed but with this right there is no legal responsibility, except obeying game laws, and little moral recognition of responsibility for its welfare. The State on the otherhand is charged with responsibility for the welfare of wildlife but has little opportunity to exercise it because wild life is produced primarily on lands managed for agricultural purposes. It is then, the land owner or farmer who has the opportunity to provide for the welfare of wildlife through his management of the land. Unfortunately there is little incentive for him to do so.

Under these circumstances it is but natural that the states have resorted to managing their wildlife largely by dividing the crop as equitably as feasible through enforcement of game laws. Although these efforts appear to have been fairly effective in dividing the crop it is clear that they have little to do with producing it. This is true of many other activities of conservation departments in which they engage in an effort to find some means of benefitting wildlife with the funds at their disposal. In our own state for example the Conservation Division expended but a little over $600,000 for operations which include wildlife management of the land (of which only a small percent was for private land) as compared to nearly $500,000 for law enforcement, nearly $300,000 for artificial propagation, nearly $150,000 for public relations and nearly $200,000 for administration out of a total budget of $1,779,000 (10). Even had the entire budget been available for activities on private land it would represent an expenditure of but a few cents an acre for this purpose.

CHART 1

CHRONOLOGICAL RECORD OF CHANGES IN HUNTING AND TRAPPING* RESTRICTIONS IN OHIO FOR PRINCIPAL GAME SPECIES

Year	Species	Bag Limit	Open Seasons	Length of Open Seasons
1829	*Muskrat*	.....	Oct. 15–May 1	199 days
1833	*Marten, mink,* muskrat, *otter*—Huron Co.	.....	Dec. 1–April 1	122 days
1840	*Beaver,* marten, mink, muskrat, otter—Lucas and Ottawa Counties.	.....	Feb. 1–April 1	60 days
1845	Sandusky County added to above.	.....	Feb. 1–April 1	60 days
1857	*Dove, flicker, grouse, prairie chicken, quail, turkey, woodcock, deer, rabbit.*	.....	Sept.15–Feb. 1	140 days
	Geese, duck	.....	Sept.15–May 1	229 days
	Bluebird, catbird, martin, mocking bird, red bird, robin, sparrow, swallow, thrush		Protected at all times	None
1861	Deer, grouse, prairie chicken, turkey.	.....	Sept. 1–Feb. 1	154 days
	Killdeer, meadow lark, quail	.....	Oct. 1–Feb. 1	124 days
	Geese, duck	.....	Sept. 1–April 15	227 days
	Woodcock	.....	July 4–Feb. 1	213 days
	Bobolink, creeper, cuckoo, finch, ground robin, indigo bird, kingbird, nuthatch, oriole, pewee or *phoebe, warbler, yellowbird*	.....	Protected at all times	None
1864	Deer	.....	Sept.15–Dec. 1	78 days
1865	Dove, rabbit (except on premise of hunter)	.....	Nov. 1–Feb. 1	93 days
	Grouse, prairie chicken, quail, turkey.	.....	Oct. 15–Feb. 4	113 days
1866	Deer	.....	Oct. 1–Jan. 1	93 days

*Names of birds common to the European countries were included despite the fact that there were no records of their having been recorded here. Probably some of these names were applied in the early days to our native birds.

Italics indicate the first time protection was afforded a species. Only significant changes in length of season and/or bag limit are recorded.

CHART 1—(Continued)

Year	Species	Bag Limits	Open Seasons	Length of Open Seasons
1867	Grouse, quail		Oct. 15–Feb. 1	110 days
	Mink, muskrat, otter		Feb. 15–April 1	46 days
	Flicker, wren		Protected at all times	None
1871	Duck		Sept. 1–Mar. 1	182 days
1873	Deer		Nov. 1–Jan. 1	62 days
	Mink, muskrat, otter (on premises of another)		Feb. 15–April 15	60 days
1874	Deer		Oct. 1–Dec. 1	62 days
	Pheasant or ruffed grouse, prairie chicken or pinnated grouse, *blue-winged teal, mallard* or *wood duck* or any other wild duck, wild goose, or brant		Sept. 1–Jan. 1	123 days
	Quail, turkey		Oct. 15–Jan. 1	79 days
	Rabbits (on premises of another)		Oct. 1–Jan. 1	93 days
	Crossbill or corncrake,* dummock,* Eur. blackbird,* great tit* or *blue tit,* grossbeak, hedge sparrow,* Hungarian robin,* nightingale,** redstart		Protected at all times	None
1875	Deer		Nov. 1–Dec. 1	31 days
1876	Bl.-wg. teal, ruffed grouse		Sept. 1–Jan. 1	123 days
	Deer		Oct. 15–Dec. 1	48 days
	Mallard or wood duck or other wild duck		Sept. 1–April 1	213 days
	Quail, turkey		Nov. 1–Jan. 15	76 days
	Woodcock		July 4–Jan. 1	182 days
1877	Deer		Sept. 20–Nov. 1	43 days
	Quail or prairie chicken		Nov. 1–Jan. 1	62 days
	Swan		Protected at all times	None
	Turkey		Nov. 1–Jan. 15	76 days
1879	Deer		Oct. 20–Nov. 20	31 days
1883	Deer		Oct. 15–Nov. 20	37 days
	Quail, prairie chicken		Nov. 1–Dec. 1	31 days
1885	Quail		Closed in Fulton Co. for 5 years.	None
	Mallard or wood duck		Sept. 1–April 1	213 days
	Other wild duck		Sept. 15–April 15	213 days
	Gray or *fox squirrel*		June 1–Feb. 1	246 days
1886	Mallard, wood and other ducks		Sept. 1–April 10	225 days
	Quail or prairie chicken		Nov. 10–Jan. 1	53 days
	Rabbit		Oct. 1–Feb. 1	124 days
	Squirrel		June 1–Jan. 1	214 days
	Turtle dove		Aug. 1–Jan. 1	153 days
1888	Prairie chicken, ruffed grouse, any wild duck		Sept. 1–Dec. 15	106 days
	Quail		Nov. 10–Dec. 15	36 days
	Squirrel		June 1–Dec. 15	198 days
	Turkey		Oct. 1–Dec. 15	76 days
	Woodcock		July 15–Nov. 1	110 days
1890	Any wild duck		Sept. 1–April 10	222 days
	Deer		Oct. 15–Dec. 15	62 days
	Gray, fox or black squirrel		July 1–Dec. 15	168 days
	Mink, muskrat, otter		Mar. 1–April 15	46 days
1896	Deer, *ringnecked pheasant*		Closed to 1900	None
	Dove, rabbit, squirrel		Sept. 1–Dec. 15	106 days
	Rail		Sept. 1–April 10	222 days
	Ruffed grouse, turkey		Nov. 10–Dec. 15	36 days
	Woodcock		July 4–Nov. 15	135 days
1898	Duck		Sept. 1–April 15	227 days
1900	Coot, duck, rail		Nov. 10–Dec. 1	22 days|54
			Mar. 10–April 10	32 days|days
	Deer		Nov. 10–Dec. 16	37 days
	Prairie chicken, quail, rabbit, ruffed grouse, squirrel, woodcock		Nov. 10–Dec. 1	22 days

CHART 1—(Continued)

Year	Species	Bag Limits	Open Seasons	Length of Open Seasons
1902	Pheasant, prairie chicken, ruffed grouse	*6*	Protected to Nov. 10, 1904; subsequently to 1917	None
	Rail		Nov. 10–Dec. 1	22 days | 64
			Mar. 10–April 20	42 days / days
	Skunk		Nov. 1–Feb. 1	93 days
	Squirrel	*10*	Aug. 1–Sept. 1	32 days
	Turkey		Nov. 10–Dec. 1	22 days
	Woodcock	*18*	Aug. 1–Sept. 1	32 days
1904	Duck	*25*	Sept. 15–Dec. 1	78 days | 129
			Mar. 1–April 20	51 days / days
	Geese, rail	*18*	Sept. 1–Dec. 1	92 days | 124
			Mar. 1–April 1	32 days / days
	Quail	*18*	Nov. 15–Dec. 15	32 days
	Rabbit		Nov. 15–Dec. 5	21 days
	Raccoon		Sept, 1–Mar. 1	182 days
	Squirrel	10	Sept. 15–Oct. 15	45 days
	Woodcock, dove	18	Sept. 1–Dec. 1	92 days
1906	Ducks	25	Sept. 1–Dec. 1	92 days | 143
			Mar. 1–April 20	51 days / days
	Quail	18	Nov. 15–Dec. 5	21 days
	Rail	18	Sept. 1–Dec. 1	92 days | 143
			Mar. 1–April 20	51 days / days
1908	Dove		Sept. 1–Dec. 4	95 days
	Ducks	25	Sept. 1–Dec. 31	122 days | 173
			Mar. 1–April 20	51 days / days
	Quail	18	Nov. 15–Dec. 4	20 days
	Rabbit		Nov. 15–Dec. 4	20 days
	Raccoon		Nov. 1–Mar. 1	121 days
	Squirrel	10	Oct. 1–Oct. 30	30 days
1910	Rail	18	Sept. 1–Dec. 31	122 days | 173
			Mar. 1–April 20	51 days / days
	Woodcock	12	Sept. 1–Dec. 4	95 days
1911	Deer, otter, prairie chicken, wild turkey		Reported extinct in Ohio.	
	Fox		Sept. 1–Dec. 1	92 days
	Muskrat		Jan. 1–April 1	91 days
	Quail	12	Nov. 15–Dec. 4	21 days
	Raccoon		Nov. 1–Mar. 1	121 days
	Squirrel	5	Sept. 15–Oct. 20	36 days
1913	Doves, quail, Hungarian partridge		Protected to 1915, then to 1917	None
	Ducks and geese	25	Sept. 1–Dec. 1	92 days | 143
			Mar. 1–April 20	51 days / days
	Fox		Oct. 1–Jan. 10	102 days
	Rail	12	Sept. 1–Dec. 1	92 days
	Skunk		Nov. 15–Feb. 1	79 days
1915	Duck	25	Sept. 1–Dec. 15	106 days | 157
			Mar. 1–April 20	51 days / days
	Fox		Oct. 2–Jan. 9	100 days
	Rabbit		Nov. 1–Jan. 1	62 days
	Rail	12	Sept. 1–Nov. 30	91 days
	Woodcock	12	Oct. 1–Nov. 30	61 days
1917	*Blackbird, bluejay, bobolink, buzzard, dove, eagle, gull, killdeer, mouse-hawk, nuthatch, quail, sparrow and other wild birds* other than game birds		Made songbirds, protected at all times.	None
	Ducks	25	Sept. 16–Dec. 15	91 days | 142
			Mar. 1–April 20	51 days / days

CHART 1—(Continued)

Year	Species	Bag Limits	Open Seasons	Length of Open Seasons
1917	Hungarian partridge, rinknecked pheasant, ruffed grouse	.....	Nov. 15–Dec. 4	20 days
	Mink, muskrat, opossum, raccoon	.....	Nov. 15–Feb. 1	79 days
	Rabbit	*10*	Nov. 15–Jan. 1	48 days
1919	Ducks	25	Sept. 16–Dec. 31	107 days
	Fox	.....	Oct. 2–Jan. 1	92 days
	Hungarian partridge	6	Nov. 15–Nov. 25	11 days
	Mink, opossum, raccoon, skunk	.....	Nov. 1–Feb. 1	93 days
	Muskrat	.....	Dec. 1–Mar. 1	91 days
	Rail	25 (Sora 35)	Nov. 1–Dec. 31	61 days
	Ringnecked pheasant	3 cockbirds	Nov. 15–Nov. 25	11 days
	Ruffed grouse	3	Nov. 15–Nov. 25	11 days
	Woodcock	*6*	Oct. 1–Nov. 30	61 days
1921	Fox, opossum, skunk	.....	Nov. 15–Feb. 1	79 days
	Mink, muskrat	.....	Nov. 15–Mar. 1	107 days
1923	Raccoon	.....	Nov. 15–Feb. 1	79 days
1925	Muskrat	.....	Inland,	
			Nov. 15–Mar. 1	107 days
			Lake Erie,	
			Dec. 1–Mar. 15	105 days
1927	Rabbit	5	Nov. 15–Jan. 1	48 days
	Ruffed grouse, squirrel	.....	Protected at all times	None
1928	Squirrel	4	Oct. 1–Oct. 15	15 days
	Yellowlegs	.....	Protected at all times	None
1929	Fox	.....	Nov. 15–Jan. 1	48 days
	Squirrel	4	Sept. 15—Oct. 1	16 days
	Woodcock	4	Oct. 15–Nov. 14	31 days
1930	Rail	25 (Sora 25)	Nov. 1–Nov. 30	30 days
1931	Ducks	15	Oct. 16–Nov. 15	31 days
	Hungarian partridge	4	Nov. 15–Nov. 25	11 days
	Plover (black-bellied and golden)	.....	Protected at all times	None
	Raccoon	.....	Nov. 15–Jan. 15	62 days
1932	Ducks	15	Oct. 16–Dec. 15	61 days
	Mink	.....	Inland,	
			Dec. 1–Feb. 15	77 days
			Lake Erie,	
			Dec. 1–Mar. 1	91 days
	Muskrat	.....	Inland,	
			Dec. 1–Feb. 15	77 days
			Lake Erie,	
			Dec. 15–Mar. 15	91 days
1934	Ducks	12	Oct. 4–Dec. 8	66 days
1935	Ducks	10	Oct. 21–Nov. 19	30 days
	Fox	.....	Nov. 15–Feb. 1	79 days
				Southern counties, open elsewhere
	Mink	.....	Inland,	
			Dec. 1–Feb. 1	63 days
			Lake Erie, closed"	None
	Rail	15 (Sora 25)	Nov. 1–Nov. 19	19 days
1936	Ducks	10	Nov. 1–Nov. 30	30 days
	Mink	.....	Lake Erie,	
			Dec. 15–Mar. 1	77 days
	Muskrat	.....	Inland,	
			Dec. 1–Feb. 1	63 days
	Rail	15 (Sora 25)	Sept. 1–Nov. 30	92 days

CHART 1—(Continued)

Year	Species	Bag Limits	Open Seasons	Length of Open Seasons
	Ringnecked pheasant	2 cocks 4 possession	Nov. 15–Nov. 26	12 days
	Squirrel	4	Oct. 1–Oct. 15	15 days
	Woodchuck	.....	Protected, March 1 to June 30	
1937	Ducks	10	Oct. 9–Nov. 7	30 days
	Mink	.....	Lake Erie, Dec. 15–Feb. 1	49 days
	Opossum, skunk	.....	Nov. 15–Jan. 15	62 days
	Squirrel	.....	Sept. 25–Oct. 10	16 days
1938	Hungarian partridge	4	Nov. 15–Nov. 30	16 days
	Mink, muskrat	.....	Inland, Nov. 15–Jan. 15	62 days
			Lake Erie, Dec. 15–Mar. 15	91 days
	Rabbit	4	Nov. 15–Jan. 2	49 days
	Ringnecked pheasant	2	Nov. 15–Nov. 25	11 days
	Ruffed grouse	2	Nov. 15–Nov. 30	16 days
	Squirrel	4	Oct. 1–Oct. 15	15 days
1939	Ducks	10	Oct. 22–Dec. 5	45 days
	Fox	.....	Nov. 15–Jan. 15	62 days
	Hungarian partridge	4	Nov. 8–Nov. 30	23 days
	Rabbit	4	Nov. 8–Jan. 1	55 days
	Raccoon	6	Nov. 15–Jan. 1	48 days
	Ringnecked pheasant, ruffed grouse	2	Nov. 8–Nov. 30	23 days
	Squirrel	4	Sept. 25–Oct. 10	16 days
1940	Hungarian partridge	4	Nov. 15–Nov. 30	16 days
	Ringnecked pheasant, ruffed grouse	2	Nov. 15–Nov. 30	16 days
1941	Ducks	10	Oct. 16–Dec. 4	50 days
	Fox	.....	Nov. 15–Feb. 1	79 days
	Mink, skunk	.....	Dec. 1–Jan. 15	46 days
	Muskrat	.....	Inland, Dec. 1–Jan. 15	46 days
			Lake Erie, Dec. 15–Mar. 15	91 days
	Raccoon	6	Nov. 15–Jan. 15	62 days
	Squirrel	4	Sept. 15–Sept. 30	16 days—southern
			Sept. 22–Sept. 30	9 days—northern
	Woodcock	4	Oct. 10–Oct. 24	15 days
1942	Fox	.....	Nov. 20–Feb. 1	74 days
	Hungarian partridge	4	Nov. 20–Dec. 5	16 days
	Ringnecked pheasant, ruffed grouse	2	Nov. 20–Dec. 5	16 days
	Muskrat	.....	Inland, Nov. 20–Jan. 15	57 days
			Lake Erie, Nov. 20–Mar. 15	116 days
	Rabbit	4	Nov. 20–Jan. 5	47 days
1943	Deer (Restricted to Scioto, Adams and Pike Counties)	1 buck	Dec. 6–Dec. 18	13 days
	Ducks	10	Sept. 25–Dec. 3	70 days
	Hungarian partridge	4	Nov. 19–Dec. 4	16 days
	Mink, muskrat	.....	Inland, Nov. 15–Jan. 15	62 days
			Lake Erie, Nov. 15–Mar. 15	121 days
	Rabbits	4	Nov. 19–Jan. 11	54 days
	Ringnecked pheasant, ruffed grouse	2	Nov. 19–Dec. 4	16 days
	Skunk	.....	Nov. 20–Mar. 15	116 days
	Wilson's snipe	.....	Protected at all times	None

CHART 1—(Continued)

Year	Species	Bag Limits	Open Seasons	Length of Open Seasons
1944	Deer	1 buck	Dec. 4–Dec. 9*	6 days
	(Restricted to Scioto, Adams and Pike Counties)			
	Ducks	10	Sept.20–Dec. 8	80 days
	(Bag limit also 5 mallards, pintails, widgeons, single or in the aggregate)			
	Hungarian partridge	4	Nov.17–Dec. 2	16 days
	Mink, muskrat		Inland,	
			Nov.17–Jan. 20	65 days
			Lake Erie,	
			Nov.17–Mar. 1	105 days
	Opossum, skunk		Nov.17–Jan. 20	65 days
	Rabbit	4	Nov.17–Jan. 13	58 days
	Raccoon	2	Nov.17–Jan. 20	65 days
	Red fox (in 14 S. E. Ohio Counties). Elsewhere open at all times.		Nov.17–Jan. 13	58 days
	Ringnecked pheasant, ruffed grouse	2	Nov.17–Dec. 2	16 days
1945	Coot, merganser	25	Sept.20–Dec. 8	80 days
	Deer	1 buck	Dec. 3–Dec. 8	6 days
	Ducks	10	Sept.20–Dec. 8	80 days
	Geese	4	Sept.20–Dec. 8	80 days
	Hungarian partridge, pheasant, rabbit		Closed until 11 A. M. opening day	
	Mink, muskrat		Inland,	
			Nov.15–Jan. 20	67 days
			Lake Erie,	
			Nov.15–Mar.15	121 days
	Opossum, raccoon, skunk		Nov.15–Jan. 20	67 days
	Rails	15 (Sora 25)	Sept. 1–Nov.30	91 days
	Woodcock		Oct. 10–Oct. 24	15 days
1946	Deer		Protected	None
	Ducks	7	Oct. 26–Dec. 9	45 days
	Geese	2	Oct. 26–Dec. 9	45 days
	Hungarian partridge	2	Nov.15–Nov.30	16 days
	Mink, muskrat		Inland,	
			Nov.15–Jan. 15	62 days
			Lake Erie,	
			Nov.15–Mar.15	121 days
	Opossum		Nov.15–Jan. 15	62 days
	Rabbit	4	Nov.15–Jan. 1	48 days
	Raccoon	2	Nov.15–Jan. 15	62 days
	Skunk		Nov.15–Jan. 15	62 days
			Except in 13 S. E. Counties	None
	Squirrel	4	Sept.14–Sept.28	15 days
1947	Coot, merganser	25	Oct. 21–Nov.19	30 days
	Deer (in 8 N. E. Counties)	1	Dec. 15–Dec. 20	6 days
	Ducks, geese	4	Oct. 21–Nov.19	30 days
	Hungarian partridge, skunk		Protected	None
	Pheasant	2	Nov.15–Nov.22	8 days
	Rabbit	4	Nov.15–Dec. 13	29 days
	Squirrel	4	Sept.13–Sept.27	15 days

DISCUSSION AND SUMMARY

Emphasis in this paper has been placed on the apparent natural decline and rise of certain game populations in the state in relation to the enforcement of hunting restrictions and land use and social changes. It has not been the writer's intent

to minimize the importance of hunting restrictions but rather to point out their limitations in accomplishing the objectives for which they have been employed; namely perpetuation and increase of the species protected and sharing of the crop. The writer is convinced that regulations are necessary to assure an orderly and fairly distributed harvest of the wildlife crop but that their use should be tempered with recognition of their limitations of which the following are important examples:

1. Enforcement of hunting restrictions even to the extent of completely closed seasons has not been effective in halting the decline of wildlife suffering from habitat depletion. Most if not all wildlife declines in Ohio have been of this type. The history of deer, grouse, squirrels and wild turkey are examples.
2. The chief values of hunting restrictions appear to be:
   a. Preservation of brood stock. This is an assumed value as there is no clear evidence that hunting according to present custom is an effective means of reducing populations below their capacity to recover quickly *under favorable environmental conditions*. This is particularly true of species with a high biotic potential and the ability to seek refuge when pursued by the hunter. The cottontail rabbit in a brushy pasture is a good example. Unrestricted hunting might produce different results although the effect of diminishing returns from declining populations should tend to keep hunters out of the field.
   b. An equitable distribution of the supply of naturally produced wildlife. Limited open seasons and bag limits assure somewhat equal opportunity for the majority of hunters to be in the field at the same time in competition for the available crop.
3. The chief factor determining long time trends in game populations in Ohio is land use. Only in so far as the major use of the land can be modified to meet the needs of wildlife can any appreciable influence on game populations be expressed. Hunting restrictions, artificial propagation, predator control, winter feeding and related efforts are incidental compared to natural production. The land operator whether he be managing public or private land determines the use to which it is put. His use of the land can be modified to benefit wildlife if suitable incentives are provided. We do not at present seem to have any substantial means of providing these incentives.

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GALVANOTAXIS OF PARAMECIA: A STUDY THROUGH THE USE OF BALANCED SQUARE WAVES OF FREQUENCY THRESHOLDS IN RELATION TO CURRENT DENSITIES

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INTRODUCTION

Parmecia have been widely used for behavioral studies in the fields of animal and cellular galvanotaxis. However, in any quantitative study of living material a major problem has been to maintain all phases of the environment excepting for the one variable being studied. In previous papers (Goldston and Miller, 1947;

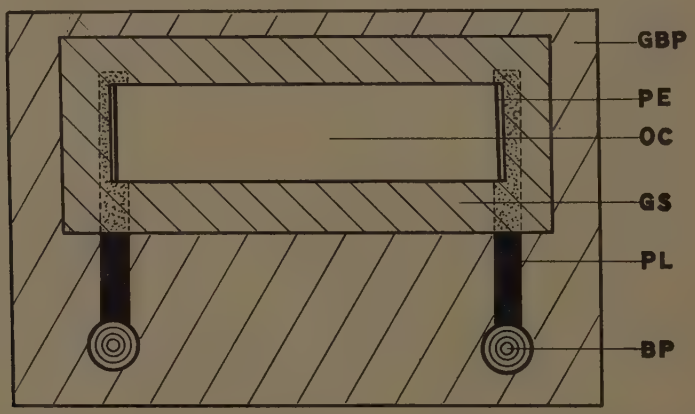

FIG. 1. Glass observation cell with platinum electrodes. GBP, glass back plate; PE, platinum electrode; OC, observation cell; GS, glass siding; PL, platinum leads; BP, binding posts.

Miller and Goldston, 1947) the authors have demonstrated the use of balanced square waves as a means of electronic stimulation. To this type of stimulation the test organism responds only to the direction of electron flow.

We have reported in the above mentioned papers some galvanotropic responses of paramecia to balanced square waves. These studies were concerned with the relation of frequency to behavioral pattern when the current density "was sufficient to produce definite galvanotropism without any morphological distortion".

PROBLEM

In the behavior laboratory balanced square waves are applied as a means of electronic stimulation to a standard culture of *Paramecium caudatum*. This problem deals with the relation of thresholds to frequencies and current densities. At the threshold chosen the locomotor movements of the paramecia moving at right angle to the current appear normal, at the same time individuals whose long axis is parallel to current flow show an immediate avoiding reaction. This

threshold is employed due to its minimum frequency grading, thus making mid frequency readings less variable.

APPARATUS

The methods for the production of balanced square waves applicable to behavioral studies were discussed by the authors in the previously cited papers.

For this study a glass cell of original design is utilized. (See Fig. 1.) This cell is rectangular; 28 mm long, 7.85 mm wide, and 1.58 mm deep. A full width

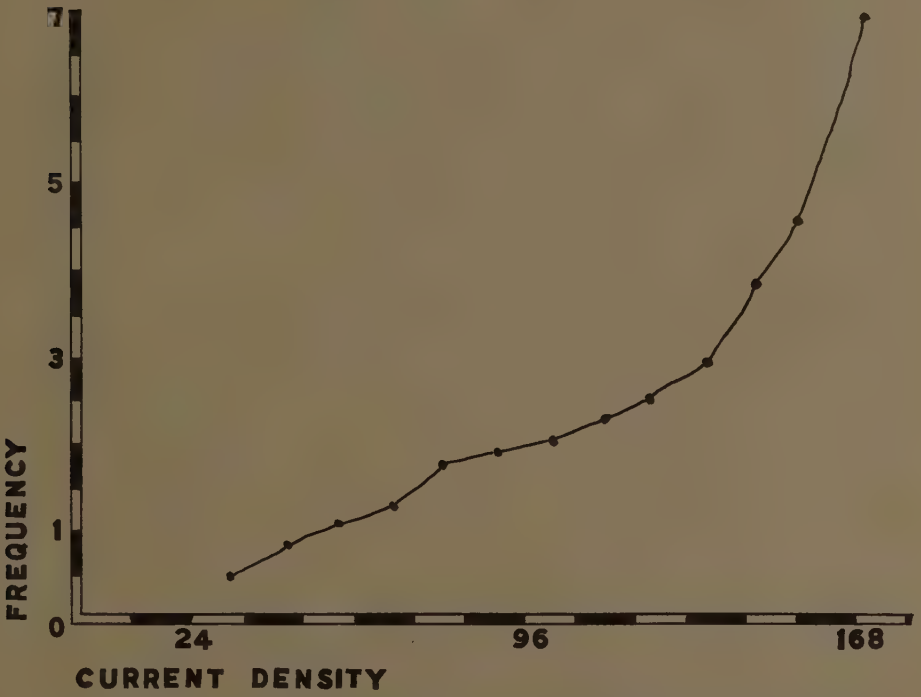

FIG. 2. Showing frequency in kilocycles per second and current density in microamperes per square millimeter necessary to produce responses discussed in text.

platinum electrode is incorporated at both ends. In use, the paramecia culture fills the entire cell which is then covered with a coverslip.

Frequency, balance, wave shape, and voltage (which is in direct proportion to current flow and current density) are checked at every step through the use of the direct deflection plates of an oscillograph. A calibrated audio frequency oscillator is employed to verify the frequency output of the square wave generator. Current levels are determined through the use of a microammeter for the various voltages.

The apparatus as described produces a form of electronic stimulation which can be quantitatively measured as to frequency, current, wave form, and voltage. The cell herein described further provides a volume of media the cross sectional area of which remains constant. With this apparatus it is possible to produce definite current densities at various frequencies. The current density is the

microamperes passing in one direction through each square millimeter of the cross sectional area of the cell during one half the square wave cycle.

APPLICATION

Paramecium caudatum from the same culture source are subjected to the above mentioned form of stimulation. Frequent changes are made of the sample being tested. However, it is significant that with identical stimulation the reaction of the used sample is at no time different from that of the fresh sample. Room temperature of approximately 25°C prevailed throughout the testing period.

The amount of current passing through the observation cell is measured in microamperes. Current changes are made in units of 40 microamperes ranging from 420 to 2100uA (See Table I, column 1). The current density is then determined for each of the thirteen variables (See Table I, column 2). Within the range of each current density studied the optimum frequency to which the paramecia respond as noted previously, is determined and recorded in Table I, column 3.

Figure 2 illustrates the relationship between the two variables which interact to produce the studied response.

TABLE I

Microamperes Passing through Observation Cell	Current Density (uA/mm²)	Mid Frequency for Threshold Noted. (c.p.s.)
420	33.9	600
560	45.2	800
700	56.5	1100
840	67.7	1300
980	79.0	1800
1120	90.3	2000
1260	101.6	2200
1400	112.9	2400
1540	124.2	2600
1680	135.5	2900
1820	146.8	3800
1960	158.1	4500
2100	169.4	7000

SUMMARY

Electronic stimulation in a variety of forms has been employed in behavioral studies. In this paper the authors describe the effect of balanced square waves at varying frequencies and current densities upon *Paramecium caudatum*. In this experiment a specific reaction is selected as a constant the variables being frequency and current density. The table and graph clearly illustrate that the frequency threshold for the selected reaction is determined by actual current density passing through the culture. In other words the same behavioral expression can be induced at different frequencies through the variance of the actual current passing through the organism.

In summary the responses of an organism to polarity interchange, in an electronic field, are determined not only by the frequency but also by the current density.

LITERATURE CITED

Goldston, L. S., and **J. A. Miller.** 1947. Production of balanced square waves for electronic stimulation, Ohio Journal of Science, 47(2): 59–61.

Miller, J. A., and **L. S. Goldston.** 1947. Galvanotropic responses of paramecia to balanced square waves, Ohio Journal of Science, 47(3): 127–129.

GEOLOGIC MAP OF NEWPORT TOWNSHIP

WASHINGTON COUNTY OHIO

by William H. Smith

GEOLOGICAL SURVEY OF OHIO

John H. Melvin, State Geologist

1948

Base from U.S. Geological Survey Topographic Maps

Scale 1/62500

0 1 2

EXPLANATION

DUNKARD
Top of Waynesburg coal

MONONGAHELA
Base of Pittsburgh coal

CONEMAUGH

STRUCTURE CONTOURS
Showing elevations of Uniontown coal

GEOLOGY OF NEWPORT TOWNSHIP, WASHINGTON COUNTY, OHIO

WILLIAM H. SMITH,
Geological Survey of Ohio,
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INTRODUCTION

Newport Township has an area of 36 square miles and lies within the Appalachian plateau physiographic province in the eastern part of Washington County, Ohio. The township borders the Ohio River, and lies just a few miles upstream from the city of Marietta, (see Geologic Map, Plate I). Geologically this township is of particular interest because it is here that the Burning Springs anticline of West Virginia crosses the Ohio River to form the Newell Run uplift of Ohio which is one of the most marked structural features in the eastern part of this State, and along which an important oil field is located.

Field work in the area was done in connection with the summer mapping program of the Geological Survey of Ohio during the summer of 1947, and a report on the geology of the township was prepared by the writer as a masters thesis at Ohio State University during the winter of 1947–8.

This paper is intended to bring out some of the more important facts concerning the structure and stratigraphy of Newport Township, gained as a result of the writer's geological work in the area. No previous geologic work in the township has been sufficiently detailed to clearly establish the structure of the Newell Run uplift, and to supply outcrop maps of the coal beds, details of their thickness and character, and intervals between the coals and other key horizons.

Rocks between the middle of the Conemaugh and the upper Permian are exposed within the area and comprise about 800 feet of strata consisting mainly of shales, sandstones, limestones, mudstones, clays, and coals. The nomenclature and correlation of these strata are shown by means of graphic sections on Plate II. The coal beds are mostly thin and of poor quality, but may offer more promise in the future as a source for synthetic fuels manufactured from low grade coal deposits. Other valuable deposits are the limestones and calcareous mudstones which contribute to the agricultural value of the soils. Abundant sandstone is present, but it is mostly of poor quality, and little use has been made of it up to the present. The Newell Run oil field, located along the uplift, has been active since 1890, and is still the center of considerable drilling activity, although not to as great an extent as in the past when the oil pools of this area supplied a major part of Ohio's petroleum production.

STRATIGRAPHY

Approximately 800 feet of strata is exposed in Newport Township. This includes the strata in the upper half of the Conemaugh series and all of the Monongahela series of the Pennsylvanian system. Rocks in the Dunkard series of the Permian system overlie the Pennsylvanian, and comprise the youngest deposits in the area. Following is a brief account of the stratigraphy and lithology of each of these series in the area under discussion.

CONEMAUGH SERIES

The Conemaugh rocks are exposed over an area of about three square miles near the crest of the Newell Run uplift. This structure brings to the surface the Cow Run sandstone and other middle Conemaugh rocks that are generally more

than 250 feet below the level of the Ohio River in this part of eastern Ohio. Lithologically, the Conemaugh rocks consist mostly of sandstone, sandy shale, calcareous mudstone, thin beds of limestone, clay, and coal. The Ames limestone is exposed at the crest of the uplift, and represents the youngest known marine deposit in the section. Other important members in the Conemaugh deposits of the area are: the Harlem coal, the Elk Lick coal and limestone, the Clarksburg coal and limestone, and the Upper Pittsburgh limestone.

MONONGAHELA SERIES

Monongahela strata are exposed over the major part of the township, and the lithology of its strata is essentially the same as in the underlying Conemaugh except that there are more coal beds, and the strata are in general more uniform in character and interval. In Newport Township the Monongahela series contains shale, sandstone, mudstone, limestone, clay and coal. Of these the shales and sandstones comprise by far the largest proportion of the rocks. The limestones are few and thin, and the coals, with the exception of the Meigs Creek, which has been mined to some extent locally, are thin and of no value except as stratigraphic markers. The average thickness of the Monongahela strata in Newport Township is 240 feet, and the distribution of the rocks in this series is shown on the geologic map (Plate I).

Important marker beds in the Monongahela series are: the Pittsburgh coal and its overlying limestone, the Redstone and Fishpot coals, the Meigs Creek coal, the Uniontown coal, and the Waynesburg coal which comprises the uppermost bed of the series.

The extent and line of outcrop of the Pittsburgh coal, or where missing its horizon, marked by a disconformity at the top of the Conemaugh series, is shown by the black line representing the Conemaugh-Monongahela boundary on the accompanying map (Plate I) of this paper. Examination of the map shows that the outcrop of the Pittsburgh coal in Newport Township is restricted to a small area of about three square miles, where it is brought to the surface along the Newell Run uplift. In much of this area, especially along the axis of the uplift in Secs. 3, 4, and 33, ans along the west flank of Secs. 9 and 10, no trace of the Pittsburgh coal is found. In places the Upper Pittsburgh sandstone, or limestones that are normally found in the Pittsburgh coal–Upper Pittsburgh sandstone interval elsewhere in the township and throughout Washington County, rest disconformably upon the Upper Pittsburgh limestone. Where this situation prevails the Pittsburgh coal horizon was mapped at the contact of the Upper Pittsburgh limestone with the overlying Monongahela strata.

In Newport Township, and in general throughout the area of Monongahela outcrop in Washington County, the Uniontown coal is not of commercial value, but is a persistent formation and offers the most satisfactory single stratigraphic marker within the Monongahela series. It is for this reason that the structure contours on the accompanying geologic map (Plate I) are drawn on this horizon. The Uniontown coal varies within the township from a thin, carbonaceous streak to a coaly zone more than eight feet thick. These are, however, the extremes, and in the average section the coal zone has a thickness of one to three feet, the major portion of which consists of partings of various sorts. The most important factor contributing to the value of the Uniontown zone as a stratigraphic marker is its characteristic lithology. This very frequently is so pronounced that the geologist who is familiar with the section is able to locate his stratigraphic position in the field on the basis of the lithology of this coal bed without reference to any other members of the series; and often this may be done even where the coal is poorly exposed.

The two most distinguishing lithologic units found in the Uniontown coal member are: first, a coaly limestone often found near the center of the coal bed,

and second, a hard, fissile, carbonaceous or coaly shale overlying the limestone. The limestone is usually black and coaly, fine-grained, often nodular or lenticular, and together with the overlying shale generally contains ostracod carapaces, which frequently are so profusely abundant in the rock that it might well be termed an ostracod coquina. The thickness of this limestone seldom exceeds 4 to 6 inches, and where the Uniontown coal zone becomes thin the limestone is generally wanting. The black fissile shale bed is found a few inches to one foot or so above the limestone bed, and is often persistent in exposures where the limestone is entirely wanting. It is a jet-black, fissile, coaly shale, that is characterized by its hardness and by its tendency to split into paper-thin laminae. Its great value as a marker of the Uniontown horizon lies in its resistance to weathering, and to the manner in which it splits up into thin laminae that cover the weathered slope of outcrops that would be extremely difficult to locate without the aid of these shale chips.

The Benwood limestone, in the lower half of the Monongahela series, may offer an important future source of agricultural lime to the farmers of the area, and the Lower Sewickley and Sewickley sandstones have limited local use. The remainder of the Monongahela series consists mainly of shale and thin-bedded sandstones.

DUNKARD SERIES

Rocks of the Washington group of the Dunkard series are present in all of Newport Township except in the area of the Newell Run uplift. Over the uplift they have been eroded while around the flanks of the uplift the Pennsylvanian-Permian boundary is near the hilltops, and dips to lower elevations to the north, east and west. The Pennsylvanian-Permian boundary is shown by the black line on the geologic map accompanying this paper, and the area underlain by Permian rocks is shown by the solid green color. The rocks in the Dunkard series are quite variable in thickness and lithology. There are sandstones, shales, limestones, and coal; these strata undergo rather rapid changes in facies, and contain few persistent marker beds. There is a preponderance of shale and thin-bedded sandstones that often are gradational one into the other. These lithologically similar beds occur in various stratigraphic positions, and make the Permian strata exceedingly difficult to classify and define. In the eastern part of the township where the rocks are relatively flat-lying the base of the Permian system is 130 to 160 feet above the level of the major streams, and about 150 feet below the hilltops. In the northwestern part of the township the strata rise due to the influence of the Cow Run uplift and the Permian rocks are found nearer the hilltops. In southwestern Newport Township and in southeastern Marietta Township, the rocks dip toward the Parkersburg syncline, so that in the extreme southwest corner of Newport Township, the Washington coal is found near stream level. This places the base of the Permian about 140 feet lower, and allows for 550 or more feet of Permian strata in the higher hills of that area. The rocks in the lower part of the Green group are, therefore, due near the hilltops in the southwest corner of the township, but outcrops in this small area are so few and so poor that no detail concerning the rocks of this group was obtained.

STRUCTURE

The area and extent of the Newell Run uplift and other structural features in Newport Township are shown by structure contours on the geologic map (Plate I). These contours give the elevation above sea level of the base of the Uniontown coal horizon, which is the most persistent, and the most widely distributed stratigraphic datum plane in the township. Examination of the map shows that

the axis of the Newell Run uplift enters Ohio in the NW¼ Sec. 33, and extends north-northwestward into Sec. 11, where the structure flattens and dies out. The reader will note from examination of the map that the dips on the east flank of the structure are considerably steeper than those on the west flank where the strata dip to the southwest at a rather uniform rate of about 80 feet per mile toward the axis of the Parkersburg syncline. The Parkersburg syncline, which is a very prominent structural feature in West Virginia, extends northward into Ohio with its axis crossing the Ohio River near the eastern edge of the city of Marietta, 10 miles west of the axis of the Newell Run uplift.

Another prominent structurally high area in the township is located in Secs. 18 and 24, near the northern border of the township. This structural rise is due to the influence of the Cow Run uplift, the center of which lies on Cow Run about 1 mile north of the Newport Township line. Field work was carried on in the area of the Cow Run structure by Dr. A. T. Cross who did mapping for the Geological Survey of Ohio in that region during the summer of 1947. However, the mapping of this structure has not yet been completed, and for this reason, the northward continuation and the exact trend of the structural high in Secs. 18 and 24 of Newport Township cannot be very definitely predicted on the geologic map with this report.

There is a sharp change in the trend of the anticline at or very near the Ohio River where the structure makes a sharp swing from a northeasterly trend on the West Virginia side of the river to a northwesterly trend on reaching the Ohio side. The writer had previously thought it possible that this sharp change in the trend of the structure near the Ohio-West Virginia boundary might be present only in the upper strata, and that it might not be reflected in the deeper rocks. However, regional sub-surface maps prepared by the geological department of one of the major oil companies that has done considerable research in the area, offer convincing evidence that this abrupt change in trend is present, and that it is reflected in the rocks at least to the depth of the Berea sandstone. These maps, contoured on the Berea sandstone, show a structural trend similar to that shown on the geologic map (Plate I) included with this paper. The Berea sandstone was reportedly reached in drilling at an elevation of approximately 793 feet below sea level in the NW¼ Sec. 33, at the highest point on the Ohio structure. From this point the structure contours on the Berea sandstone indicate that the structure plunges northwestward in a manner similar to that shown by the structure contours on the map (Plate I) with this paper. The structural high on the Berea does not, however, plunge out to as great an extent as is indicated in the surface rocks, but rather it continues on, rising again to 1,070 feet below sea level on reaching the Cow Run uplift. From the Cow Run uplift northwestward, the Berea structure flattens into a broad low arch that continues to express itself in the structure contours until it reaches a point near the Washington-Noble County line. This northwest trend, shown on the structure map of the Berea sandstone, continues northwestward from the Newell Run uplift, through the Cow Run uplift, and northwestward to the Washington-Noble County line. This trend is nearly parallel to the trend of the Cambridge arch, and to the trend of the Parkersburg syncline, which are two of the major structural features in eastern Ohio.

Although detailed maps are not yet completed showing the structure of the Cow Run uplift as expressed in the surface rocks, it appears to have an essentially east-west axial trend. If this is correct then the trend of the Cow Run uplift is approximately at right angles to the northwest trend shown for the Newell Run uplift which, as expressed in the surface rocks, dies out on the west fork of Newell Run about 2½ miles north of the Ohio River, and two miles southeast of the Cow Run uplift.

ECONOMIC DEPOSITS

On the whole, there is little in the way of geological deposits except oil and gas in Newport Township that is of any commercial value. In the past, the coal beds have yielded some coal for local use, but they are not being worked at the present due to the thinness and poor quality of the deposits. These low grade coals may, however, be used at some future date in the production of synthetic fuel. Aside from the coal seams and petroleum products, the sandstones and limestones are the only other commercially useful deposits. There is a great deal of sandstone present in the township, but none is of much value for building stone or other economic use. There are no appreciably thick limestone deposits in Newport Township, and those present are in general too thin to be successfully quarried for use as agricultural lime or other purposes. A possible future supply of agricultural lime, which may be obtainable from the Benwood member, is suggested in the discussion of the limestone deposits.

COAL DEPOSITS

On the generalized stratigraphic section of Ohio (Plate II), are shown seventeen coal horizons that occur within the rock section exposed in Newport Township. Although all of these are not recognized, most of them can be identified, and the graphic sections on Plate II indicate those that are present and their correlation within the township. Of these the only ones that offer promise from an economic point of view are the Meigs Creek, Uniontown, and Washington, each of which will be discussed briefly.

The Meigs Creek coal was mined on Cow Run in the early days of oil exploration to furnish power for the steam drilling rigs, and is at present mined commercially at Moss Run located 1½ miles north of Cow Run, and three miles north of the Newport Township boundary. Along Bolivian Run in the S½ Sec. 6, Newport Township, there are several abandoned drift mines in which there was reportedly two and one-half to four feet of mineable Meigs Creek coal. None of these mines has been active since the depression years of 1930–1936, and it is reported that in these mines the coal bed was rather irregular, and that a number of clay rolls and cutouts were encountered in the mining. Over the major part of Newport Township the Meigs Creek does not attain sufficient thickness to be mineable, and in the area near Bolivian Run it is only of marginal mining thickness and does not warrant the effort necessary to get it out except during times of shortage or depression. It is therefore doubtful that the Meigs Creek deposits will ever warrant future development, except perhaps in connection with underground gasification projects that might be located in the Moss Run mining district a few miles to the north.

The Uniontown coal, which is found on the average of 110 feet above the Meigs Creek, is of no economic importance in Newport Township at the present time, although with the recent advancements in synthetic liquid fuels manufacture from low grade coals it is possible that in the future it may be of use as a source of raw material for this purpose. In the western half of the township exposures of the Uniontown indicate a thickness that would perhaps warrant analysis of the full zone of coal and coaly shales to determine their yield of oil per ton, after which coring would be advisable if the analysis proved favorable.

The Washington coal together with the Meigs Creek comprise the only two mineable coal beds in Newport Township. The Washington coal has been mined in the hill north of Long Run in the SW¼ Sec. 22 at an elevation of 928 feet. The mine is now caved in, but the owner reports that the coal bed attained a maximum thickness of forty-nine inches in this mine. He states, however, that the coal thinned rapidly after the drift entry had been driven twenty or thirty feet into the

hill, and that because of the thinning the mine was abandoned. The rocks dip to the southwest in this area due to the influence of the Parkersburg syncline, which brings the coal nearer stream level in the southwestern corner of the township, where the Washington coal has also been mined in a small way for house coal. The coal is reported to have an average thickness of about two feet in these mines, but because of its thinness and poor quality it has never warranted commercial mining. The Washington coal generally has a high ash content throughout its extent in eastern Ohio, and those who have mined this coal in Newport Township state that although it is soft, it burns well, but leaves a great deal of ash.

SANDSTONE DEPOSITS

The sandstone deposits in Newport Township have not been found of much economic use up to the present. Unless the area becomes industrialized, and new uses are found for the sandstones, there probably is little chance that they will be used to any large extent in the future. Most of the sandstone deposits are rather soft and are either thin-bedded or shaly in character. Both of these factors detract from the value of the stone for building purposes. No quarries are known to have operated in the township, and about the only use made of the sandstone up to the present has been very limited local uses, such as for house and barn foundations, bridge abutments, and crushed rock for road building. For most of these purposes the stone at hand has been used and thus nearly all of the sandstones that outcrop within the township have been used at one place or another.

Sandstones in the Conemaugh series outcrop over such a small area that no particular use has been made of them. The Monongahela sandstones, which include the Upper Pittsburgh, the Lower Sewickley, the Sewickley, and at places the Arnoldsburg and Uniontown, have found more widespread use than the Conemaugh sandstones due to their greater distribution. Of these the Sewickley receives the greatest amount of use, but it weathers so rapidly that it is doubtful that any commercial use except perhaps sand manufacture could be made of it.

The Permian sandstones in Newport Township, which include mainly the Waynesburg and the Mannington, are either too flaggy, or else too soft to be of much value. The Upper and Lower Marietta sandstones come into the section along the Ohio River in the southwest corner of the township where they form prominent cliffs along the river bluff. Both of these sandstones are quarried extensively a few miles farther west near the city of Marietta, where the stone is used mainly for the manufacture of grindstones. The Marietta sandstones in Newport Township do not, however, attain the thickness and quality that they have near Marietta, and will probably not find use unless the Marietta deposits become depleted.

LIMESTONES DEPOSITS

In the exposed rocks of Newport Township there are only a few thin nodular beds of limestone, of which the Arnoldsburg is the only important one. There are, however, thick deposits of calcareous mudstone in the Lower Monongahela and in the Conemaugh that furnish abundant lime to the soil along their outcrop and that may offer a future source of agricultural lime for the township. The economic value of these deposits lies in their use as a source of lime for agricultural purposes, but little use has been made of them up to the present. However, there is a decided need for lime in most of the soils of the township, and an adequate supply of lime would add much to the economy of the area by permitting the raising of more alfalfa and other legume hay crops as well as other agricultural products that do best in well limed soil.

In general, the Arnoldsburg is not of sufficient thickness to be quarried out for crushing, and for this reason has not been used to any extent. One account re-

garding its use was cited to the writer by a farmer who gathered field stones weathered from the outcrop of the Arnoldsburg and had them crushed for agricultural lime. The Benwood member, on the other hand, has an extensive distribution over all but the southwest corner of the township, and attains a thickness of from thirty to sixty or more feet. It is a highly calcareous red mudstone containing small pellets of hard, white limestone. In the writer's opinion this mudstone may find extensive use in the future as a cheap and readily available source of agricultural lime.

In view of the abundance and availability of the Benwood member in Newport Township, a thorough study of it seems advisable in order to determine its acid neutralizing power and methods by which, if it proves to be of value, it might be mined and distributed to the farmers in the area.

OIL AND GAS DEPOSITS

Newport Township has long been important as an oil and gas producing area, and many hundreds of wells have been drilled there since the initial well was drilled in 1890. No complete record of the number of wells drilled in the township, or production figures, etc., concerning the many wells that have been drilled is known to the writer and it is doubtful if any such record has ever been maintained, although Bownocker[1] states that there were 300 producing wells in the township in 1900. The oil fields of the township are old fields that had their major development during the period between 1890 and the early 1900's. The area is, however, still active, and there are probably several hundred wells in the township that are producing at the present time. Most of these are old wells that only produce a few barrels a week, but are still worth being pumped. New wells are being drilled in the township, but seldom produce more than five to ten barrels a day, and are operated almost exclusively by individuals and small companies made up of local citizens.

The principal productive area in Newport Township is the Newell Run pool, located in the area of the Newell Run uplift, and extending northwestward into Sec. 13 of Independence Township. This practically unites the Newell Run pool with the Cow Run pool. There are also two other minor producing areas in the township. One is the Sand Hill pool, located principally in Marietta Township, but extending eastward into Secs. 33, 27, and 22 of western Newport Township, and the other is the Bosworth pool, located on the east side of the Newell Run uplift. There are also numerous other producing wells in the township that do not fall within the limits of either of the above three producing areas. These wells are scattered throughout the township and do not follow any noticeable trend or pattern.

The production in Newport Township is obtained primarily from the First Cow Run and the Berea sands. The First Cow Run sandstone belongs stratigraphically about in the middle of the Conemaugh series. It was the principal producing sand in the early days of the field, and is still producing in a number of wells. The up-dip of the rocks along the anticline brings the Cow Run sandstone above the level of the Ohio River near the mouth of Conley Run in the NW $\frac{1}{4}$ of Sec. 33, where a 29-foot cliff of the sandstone is exposed. From here the northwest plunge of the anticline carries the sandstone under cover where it is reported by Bownocker[2] to be struck at a depth of 300 feet on Peggs Run in Sec. 11, and at a depth of 478 feet on Eightmile Creek, in the NW $\frac{1}{4}$ of Sec. 18.

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[1]Bownocker, J. A., "Occurrence and Exploitation of Petroleum and Natural Gas in Ohio," Ohio Geol. Survey, 4th ser., Bull. 1, pp. 181–185, 1903.

[2]Bownocker, J. A., "Occurrence and Exploitation of Petroleum and Natural Gas in Ohio," Ohio Geological Survey, 4th ser., Bull 1, pp. 181–185, 1903.

MONONGAHELA AND PERMIAN SECTIONS

CONEMAUGH SECTIONS

GENERALIZED SECTION OF OHIO

Series

Dunkard

PERMIAN SYSTEM

PENNSYLVANIAN SYSTEM

Conemaugh

Monongahela

Sandstone, *Upper Marietta*
Shale, siliceous
Coal, shaly, local, *Washington "A"*
Shales, local
Limestone, *Middle Washington Cresent Reds*
Shales, soft to hard
Limestone, *Lower Washington*
Shale, calcareous
Sandstone, local, *Lower Marietta*
Shale, siliceous
Coal, shaly, *Washington*
Shales, soft to hard
Coal, shaly, *Little Washington*
Shales, irregular
Sandstone, local, *Mannington*
Shales, variable
Coal, unsteady, *Waynesburg "A"*
Shales, soft to hard
Sandstone, rather steady, *Waynesburg*
Shales, gray, siliceous
Limestone, *Elm Grove*
Shale, gray, *Cassville*
Coal, fair, purity, *Waynesburg No.* 11
Shale, and sandstone, *Gilboy*
Coal, persisent, *Little Waynesburg*
Limestone and marly shale, *Waynesburg*
Shale or sandstone, *Uniontown*
Coal, *Uniontown No.* 10
Shale, siliceous and limestone, *Uniontown*
Sandstone, *Arnoldsburg*
Coal, wanting, *Arnoldsburg*
Limestone and calcareous shale, *Arnoldsburg*
Shale, green, or shaly sandstone, *Fulton*
Limestone and calcareous shale, *Benwood*
Sandstone, local, *Sewickley*
Coal, *Sewickley, Mapletown, Meigs Creek No.* 9
Clay, shale, calcareous
Sandstone, *Lower Sewickley*
Coal, Unsteady, *Redstone, Pomeroy*
Limestone and marly shale, *Redstone*
Coal, persistent, thin, *Fishpot*
Limestone and marly shale, *Fishpot*
Sandstone, local, *Upper Pittsburgh*
Coal, persistent, *Pittsburgh No.* 8

Limestone and shale, *Fishpot*
Coal, Unst[eady] stone, *Pomeroy*
Limestone a[nd] shale, *Redstone*
Sandstone, *Upper Pittsburgh*
Coal, per[sistent] *Pittsburgh No.* 8
Limestone, irr[egular] *Upper Pittsburgh*
Clay shale
Coal, very local, *Little Pittsburgh*
Clay shale [and] local, *Bellaire*
Coal, seldom present, *Little Pittsburgh*
Shale, variable
Limestone, *Summ[it] Lower Pittsburgh*
Shales, variable
Sand[stone] coal, *Connellsville*
[Sandstone] local, *Clarksburg*
Limestone and [marly] shale, *Clarksburg*
Sand[stone] coal, *Morgantown*
Coal, [wanting, *Elk Lick*
Limestone a[nd] shale, *Elk Lick*
Shale, variable
Sha[le] ous, *Birmingham*
Limest[one] l, marine, *Skelley*
Coal, s[ometimes] ident, *Duquesne*
Shale, variable
Shale, siliceous
Limestone, s[hale] marine, *Gaysport*
Shale, siliceous
[Limeston]e, marine, *Ames*
Shale, siliceous
[Coal] ersistent, *Harlem*
Clay, calcareous
Clay shale, red, *Knob—Pittsburgh*
S[andstone] local, *Saltzburg*
Coal, local, *Barton*
Lime[stone] ruginous, *Ewing*
Shale, siliceous
[Coal] e, local, *Cow Run*

EXPLANATION

Sandstone
Clay
Coal
Siltstone
Calcareous shale
Carbonaceous shale
Shale
Limestone
Sandy shale
Marly limestone or mudstone

COLUMNAR SECTIONS OF PENNSYLVANIAN AND PERMIAN STRATA IN NEWPORT TOWNSHIP, WASHINGTON COUNTY, OHIO

by William H. Smith

GEOLOGICAL SURVEY OF OHIO
John H. Melvin State Geologist
1948

INDEX MAP SHOWING LOCATION OF SECTIONS

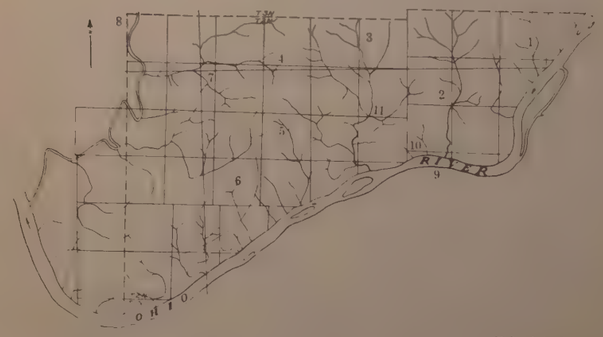

PLATE 2

EARLY DEVELOPMENT OF THE HUMAN PHARYNGEAL HYPOPHYSIS — A PRELIMINARY REPORT[1]

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Most textbooks of Embryology and of Histology generally agree on the following more or less well-known facts: (1) the hypophysis or pituitary gland occupies a depression (the hypophyseal fossa) within the sella turcica which is located on the cranial aspect of the body of the sphenoid bone; (2) the hypophysis is a composite organ consisting of two main portions, an anterior and a posterior; (3) the anterior portion is further divisible into the pars distalis (or anterior lobe proper), the pars tuberalis and the pars intermedia, the posterior portion being designated usually as the neural lobe or pars neuralis; (4) three types of cells are recognizable in the anterior lobe; namely chromophobes, or reserve cells, which lack secretory granules, acidophiles, which contain alpha or acidophilic granules and basophiles, so-called because they contain beta or basophilic secretory granules; (5) the pars anterior is derived from the distal closed end of Rathke's pouch and the pars posterior arises from the infundibulum of the hypothalamic region of the diencephalon; (6) Rathke's pouch develops as a hollow epithelial diverticulum from the roof of the embryonic oral cavity or stomodaeum; (7) the original point of union of Rathke's pouch with the oral epithelium comes to be located well back on the roof of the primitive mouth, and still later when the palate separates off the nasal fossae from the oral cavity proper its site of origin lies at the postero-superior border of the nasal septum at its junction with the roof of the nasal pharynx; and (8) the distal end or hypophyseal portion of Rathke's pouch becomes separated from the stomodaeal epithelium by the obliteration of its original connecting duct or stalk.

Obliteration of the proximal connecting portion of Rathke's pouch with the oral epithelium is a gradual process. When the para-axial mesenchyme differentiates into embryonic connective tissue in the region of the future body of the sphenoid bone the connection of Rathke's pouch with its site of implantation to the epithelium becomes elongated and is gradually reduced to a narrow duct or stalk, which is termed the hypophyseal stalk or craniopharyngeal canal. When, later on, the process of chondrification takes place in the connective tissue, by means of which the cartilaginous body of the sphenoid is formed, the pharyngeal stalk is gradually compressed into a slender epithelial strand which is said to normally degenerate and disappear.

Most textbooks of embryology fail to give much detail concerning the origin and fate of Rathke's pouch and they dismiss the subject usually by merely stating that the stalk by which Rathke's pouch was attached to the stomodael epithelium completely disappears (2, 6, 10, 13, 14, 17, 18, 19, 21). On the other hand, some authors mention the occasional persistence of remnants of the connecting stalk of Rathke's pouch (1, 4, 7, 8, 11, 22, 24). Three typical sites of locations of these remnants have been described, namely "intracranial"—within the hypophyseal fossa adjacent to the hypophysis but separated from it by cranial dura mater, "interosseous"—embedded within the body of the sphenoid bone, and "pharyngeal"—within the soft tissue in the roof of the nasal pharynx. The term "pharyngeal hypophysis" is applied to the epithelial remnant in the roof of the nasal

[1]This investigation was aided by a grant from the Ohio State University Development Fund, for which the authors make grateful acknowledgment.

pharynx as opposed to the other two which are usually considered as a "persistent craniopharyngeal canal" (8, 22).

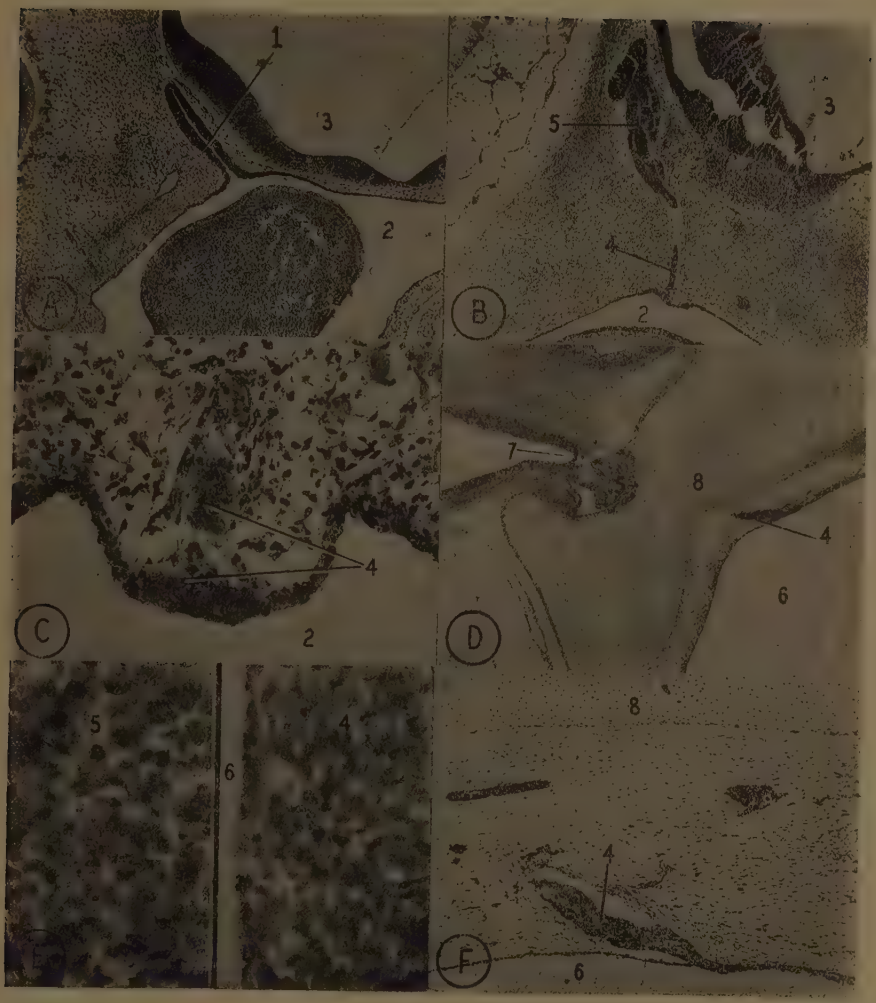
These epithelial remnants are generally considered to be anomalies or abnormalities. However, a few authors point out that the pharyngeal hypophysis is said to be constantly present (1, 4, 7, 22, 24). Thus, according to Smith and Copenhaver (24) "There occurs constantly in the vault of the nasopharynx, in man, a body of typical anterior lobe tissue. It has not been demonstrated in other species. This body lies in the midline and is elongated, its longitudinal axis being parallel to the sagittal plane of the body. It measures from 3.5 to 7 mm. in length by 1 mm. or less in diameter. The cells of the pharyngeal hypophysis are structurally identical with those of the anterior lobe and parallel them in their differentiation and development."

In view of the general agreement, among these outstanding embryologists and histologists, as to the constancy of occurrence of the pharyngeal hypophysis it seems strange that it is so frequently ignored in many textbooks of embryology, histology and human anatomy and that studies on its frequency of occurrence in the vertebrate series and on its histogenesis in man and other species have been so generally neglected. Aside from scattered reports in the literature concerning its involvement in neoplastic growths, which would appear very likely, surprisingly few papers bearing on its frequency in man and lower animals and on detail studies of its development have appeared. Haberfeld (9) reported the results of his studies on its development in a few human fetuses including the newborn; Christeller (5) reported its normal and pathological appearance in adults and in 1938 there appeared for the first time in the English literature a report of its occurrence in human autopsy material. This was by Melchionna and Moore (20) who found it in 51 out of 53 unselected autopsied bodies which they studied, ranging in age from the newborn to 69 years. These authors claimed its cellular constituents were histologically identical with those in the pars anterior of the hypophysis except the differentiated cells were relatively fewer. Hertwig (11) claimed that in many vertebrates, e.g. Selachians, the pharyngeal stalk is retained throughout life as a hollow canal which perforates the base of the skull and is united with the oral epithelium. Kingsbury (15, 16) made a detail study of it in the dog in which he claimed it occurred in almost 100% of the cases examined and mentioned that it had been reported seen in the cat (3) and rabbit. Its presence in the rat (23) and ox (12) however, has been denied.

Inasmuch as so few studies have been made of this structure, and in view of its possible involvement in pathological conditions of the hypophysis and possibly other endocrine organs, the authors have launched upon a research program to investigate its frequency of appearance in man and other vertebrates, its histogenesis and fate and eventually to determine whether or not pathological conditions or experimental procedures may affect it in any way. The present report on its early development in man is the first to come out of this projected study.

In a six mm. (about four weeks) human embryo Rathke's pouch is well defined (Fig. A). It appears in a sagittal section as a finger-like epithelial diverticulum in close relation to the floor of the fore-brain and with a narrow, slit-like lumen opening inferiorly into the oral cavity. However, in a transverse section at this stage it is, in reality, wide and flattened.

By the 12 mm. stage (about five weeks) the continuity of Rathke's pouch throughout its length is broken, its distal free end, which is destined to differentiate into the pars anterior of the hypophysis, is enlarged and its proximal end persists for some distance and retains its connection with the oral epithelium (Fig. B). Condensation of the mesenchyme in the area intervening between the remaining portions of Rathke's pouch (4 and 5) indicates the beginning of chondrification of the future body of the sphenoid and may explain the constriction of the neck of the



Photomicrographs of sections of human embryos showing stages in development of the pharyngeal hypophysis.

A. 6 mm. Human—Sagittal section—Mag. 84×—H. & E.
B. 12 mm. Human—Sagittal section—Mag. 81×—H. & E.
C. 22 mm. Human—Cross section —Mag. 387×—H. & E.
D. 25 mm. Human—Sagittal section—Mag. 44×—H. & E.
E. 50 mm. Human—Sagittal section—Mag. 778×—H. & E.
F. 80 mm. Human—Sagittal section—Mag. 84×—Hem. & Orange G.

1. Rathke's pouch.
2. Oral cavity.
3. Fore-brain.
4. Pharyngeal hypophysis.
5. Pars anterior of hypophysis.
6. Nasal pharynx.
7. Infundibulum.
8. Basi-sphenoid.

pouch. The persistent site of implantation of the proximal end of the pouch is the primordium of the pharyngeal hypophysis.

Figure C shows a magnification of the pharyngeal hypophysis (4) in a 22 mm. (about eight weeks) human embryo. The epithelial cells composing it are undifferentiated, although they exhibit evidence of elongation and proliferation at the site of implantation on the free surface of the oral epithelium. The persistent stalk is surrounded by mesenchyme with the exception of its periphery where a connective tissue capsule is differentiating and an embryonic blood vessel is making its appearance at its free distal extremity.

In an embryo 25 mm. in length (about 10 weeks) the future body of the sphenoid is cartilaginous, the sella turcica is outlined and is occupied by the future hypophysis, the pars anterior of which shows vesicle-formation, and the pharyngeal hypophysis is well marked and distinguishable from the surrounding cells, its original direction with respect to the differentiating pars anterior of the hypophysis being maintained. By this stage the palate has formed and the original site of attachment of the pharyngeal hypophysis to the epithelium of the primitive, oral cavity has shifted caudally (rather the head has grown forward from that point) so that it now lies in the roof of the nasal pharynx, where its presence has been described in the adult stage (5, 9, 20).

No evidence could be found in the present series of human embryos of the beginning of cellular differentiation in either the future hypophysis or the pharyhgeal hypophysis until the 50 mm. stage (about 12 weeks), at which time (Fig. E) the cellular constituents of both (4, 5) were almost identical and consisted of two types, one type having an oval, vesicular nucleus with relatively sparse, more or less colorless cytoplasm and the other type having a smaller, rounder and more darkly staining nucleus with more abundant, and slightly acidophilic, cytoplasm.

The oldest human embryo included in the present study was an 80 mm. (about 14 weeks) stage (Fig. F). As can readily be seen from the photomicrograph the pharyngeal hypophysis is well marked and, in comparison with previous stages, has undergone considerable hypertrophy and is quite vascular when examined under high magnification. Cellular differentiation in the pars anterior and in the pharyngeal hypophysis showed little advancement over the 50 mm. stage. A cursory examination of stages 115 mm. (about 4 months), 138 mm.(about 4½ months) and 160 mm. (about 5 months) revealed its presence and to be undergoing continued hypertrophy and increased vascularity.

Further studies of the fate of the pharyngeal hypophysis in older human embryos are in progress and will be reported in the future.

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THE USE OF THE MALE FROG TEST AS AN AID IN THE DIAGNOSIS OF RETAINED PLACENTAL TISSUE

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In a previous article (1) we pointed out the value of the male frog, *Rana pipiens*, as a *new test animal* for early pregnancy. As the number of tests increases, it still is nearly one hundred per cent correct in the first trimester of pregnancy. The more recently published work of Robbins and Parker (2) substantiates our results and clinical laboratories throughout the United States are using this test in increasing numbers. Information regarding the storage, handling and feeding of the frogs has been published in another article (3).

A New Use For the Test

During the experimental work on the male frog pregnancy test we *discovered a fact which is of great clinical importance.* It was suggested by the following history.

Case History: Mrs. R. W.—On January 5, 1948, Mrs. W. awoke at 2:00 A.M. and found that she was bleeding par vaginum. After some cramp-like pains she passed several large clots. The clots were examined and one was found to contain a small foetus measuring about 4 Cm. in length. There was no more bleeding. The first specimen of urine the next morning (January 6, 1948) was injected into two males frogs. The test was positive even though the foetus had been passed. The patient was treated conservatively; bed rest, soft diet, sedatives and Ergotrate tablets (gr. 1/320 tid). The pulse and temperature remained normal. Bleeding was slight, patient remained in bed.

On the morning of January 8, 1948 cramps and vaginal bleeding, which was more than normal in amount, occurred. The patient was hopitalized. Vaginal examination revealed a soft uterus, the cervix was dilated two finger tips and the placenta, though partially extruded, *was still adherent to the posterior wall of the lower uterine segment.* Digital removal of the placenta was not attempted. Intravenous Ergotrate did not cause the expulsion of the retained placenta. On January 9, 1948, the first morning specimen of urine was injected into two male frogs. *The test was still positive.* At noon on January 9, 1948, the patient was sent to the operating room and a dilatation and curettage was performed. A placenta measuring 7 cm. in diameter was removed, the uterus carefully curretted and packed with sterile gauze. The first postoperative urine specimen, voided at 8:00 P.M. January 9, killed two male frogs before the test could be completed. The first morning specimen voided January 10, 1948, *eighteen hours after the placenta had been removed*, was injected into four frogs. All four *frogs were negative.* The first morning specimens of urine for the next two mornings were injected into frogs and the test were *negative* on both days. The uterine pack was removed at the end of twenty-four hours. Recovery was uneventful. The patient was discharged in good condition.

From this case we inferred that:

1) The pregnancy test on the male frog (*Rana pipiens*) *is positive as long as there is live placental tissue still adherent to the uterine wall.*
2) The hormone which is responsible for the positivity of the male frog test is *produced only by the live attached placenta* and, therefore, should be called the "gametokinetic placental hormone". Such a hormone may prove to be useful in cases of infertility.

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Due to the ease, accuracy, and rapidity of the test we assumed that it could be used clinically in obstetrics as well as for the diagnosis of pregnancy. Consequently, one of us (Pickett) undertook the testing on male frogs of a series of cases at White Cross Hospital, Columbus, Ohio. While the number is not large, the results consistently demonstrate the fact that the above inferences were correct.

Investigations Undertaken

1. Every case of therapeutic abortion was to have a male frog test run both preoperatively and twenty-four hours postoperatively.

2. If possible every dilatation and currettage was to have a male frog test run preoperatively and postoperatively.

3. All cases of threatened abortion, inevitable abortion and missed abortion which were admitted to the Department of Obstetrics were to have a male frog test performed on admission and repeated, if it was suspected that there was retained placenta either attached to the uterine wall or unattached.

This procedure was followed in a series of nineteen cases.

Conclusions

1. There was only one case of therapeutic abortion in the series. The patient was hospitalized, the urine was tested on male frogs both before and after surgery. The frogs tested *positive* preoperatively and they tested *negative* twenty-four hours postoperatively.

2. There were eighteen cases of known pregnancy in which there were signs, such as nausea and vomiting, associated with cramps and vaginal bleeding or "spotting" either continuous or intermittent. Male frog tests were run on these cases. Four of them were inevitable abortions. The frog tests were *negative* before the foetus aborted. Six were "missed abortions". The frog tests were negative and the patient either was subjected to a dilatation and currettage or, if clinically improved, they were treated conservatively. *There were six cases of this kind in which the frog tests turned out positive.* These cases were considered to have the *placenta still attached* and all six were subjected to supportive treatment and bed rest. All six are *still pregnant* and in good condition. These were diagnosed *threatened abortion.* Without this test some of these surely would have been subjected to surgery and the baby lost.

3. The *missed abortion* cases, many of which would have been kept in bed for several weeks and treated expectantly, were curretted and were discharged improved in several days. The pathology reports on all such cases showed that an abortion had taken place.

4. It is believed that these cases show that the original inferences were correct and that the male frog test can be used to diagnose the detachment or death of the placenta thereby putting the differential diagnosis between "threatened abortion" and "missed abortion" on a much firmer basis and saving many babies which would have been lost through surgery.

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MYRMECOLOGICAL TECHNIQUE

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III. DDT Too Perfect an Ant Killer for the Collector's Use

For several years the writer has used ether in collecting ants but for cigarette smokers ether has the hazard of explosion. The forgetfulness and excitement accompanying the discovery of a nest of strange ants, if made while smoking, could permit the explosive mixture of ether and lighted cigarette. The ants would be in the nest opening and probably recoverable, but the collector on the free side of the explosion might be found to be of little immediate use.

In August of the past season at the University of Michigan Biological Station store we obtained an "aerosol bomb" of the pressure atomizer type and tried it on a nest of *Formica sanguinea aserva* Forel. This was a young nest with a mixture of the host ant *Formica fusca subsericea* Say. (This "slave-maker" has no slaves but the *sanguinea* queen enters a *subsericea* nest, makes friends and lets the latter rear her early brood until such a nest may be half full of red ants. Such nests are in the ground, the site for *subsericea*. Later the *aserva* queen and workers move to a log or stump, if available.) The nest was opened with a shovel and the aerosol directed onto the scampering ants. The latter did not drop dead at once but after a moment or two of slowing down died rather promptly. The mixture of yellow sand, black top-soil and gravel acted as a concealing background for the red and black *aservas* which had dark head, red thorax and black gaster. Right before our eyes they disappeared. By close scrutiny enough were recovered for identification but the special effort and extra time needed to obtain specimens relegated the aerosol bomb to the back seat of the automobile to be used later on cabin pests.

We had uncovered a collecting method which was too good. In collecting a method must be used in which the ants are merely slowed down but are not completely inactivated. A cool day, 40° F. to 60° F. is the best inactivator for most species. A moderate dosage of ether is the second best. The ant must be able to move at least a leg or antenna to be readily seen by the collector if it is on a continuous background of the usual nest debris of finely mixed colors. A collector soon learns the best dosage of ether to allow the recovery of completely etherized ants within a length of time useful in collecting. If the mixture of ants and nest debris is rolled or sifted so that artificial respiration is induced in the very lax sleeping ants they may recover at surprising speed and need a second etherization. Recovery varies greatly with temperature, slowly on cool days and with distressing speed in the hot sunshine when ether flashes dry almost instantly.

Thus ether is within the control of the collector while DDT and its mixtures with pyrethrum kill ants almost at once with no further help from struggling sleepy victims. The ant must move, even quite large species, to be seen easily. A dead ant does not move against the contrast of motionless soil. The contrast of a wiggling leg or even ant foot against a motionless background is the key principle of visibility. In the case cited, that of *aserva* the dark minors were especially difficult to locate.

In an earlier paper, Myrmecological Technique, II, we cited cyanide dust (Cyanogas) as a collecting aid for tree and bush ants. This also kills but the ants fall out of the background (tree or bush) onto a white cloth where they are easily found.

Thus DDT and its mixtures are too good in slowing ants down to a pace that renders them most easily collectable. We have tried it on only this one species. The can of mixture used was labeled the "Superla Junior Aerosol Automatic Atomizer with DDT," manufactured by the Standard Oil Company, Chicago, Ill. It contained 2.00% (a light dose) DDT, 0.25% pyrethrins and 5.75% methylated naphthalene as killing agents.

THE SIGNIFICANCE OF BLEEDING IN EARLY PREGNANCY AS EVIDENCED BY THE MALE FROG PREGNANCY TEST[1]

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The above title was taken from an article by Rutherford, published in 1942 (1). The words "male frog pregnancy test" have been substituted for "decidual biopsy."

Wiltberger and Miller in early 1948 presented a simple method for the test of the early diagnosis of pregnancy. A few months later the same method was reported by Robbins and Parker (2). The test reported by these men may be performed by any practitioner in his office, home, or hospital. It is simple to do, is accurate and inexpensive, (3). Secondly, it may be used to differentiate between threatened and incomplete abortion.

The threatened abortion rate is 16 per cent or higher, (4). If it were possible to differentiate between the patients with inevitable abortions and those with threatened abortions, the attending physician could manage each patient more intelligently. The patients with inevitable or missed abortions, if diagnosed early, would be saved long periods of bed rest and valueless medication. Patients evidencing threatened abortions would receive proper treatment, and a pregnancy which might otherwise have been lost, either from lack of therapy or by the institution of active treatment to evacuate the uterus, might be salvaged.

In the majority of cases the male frog pregnancy test differentiates in a short time between threatened abortion and inevitable, or missed abortion. In some patients the test is negative almost immediately after the onset of uterine bleeding, but becomes positive again within twelve to twenty-four hours. Hence, in the absence of cervical effacement, dilatation, and excessive uterine bleeding, conservatism may be employed and the test repeated.

While waiting to repeat the test, any of the accepted forms of anti-abortive therapy may be carried out. If the second test is negative, only twenty-four hours, at the most, will have been lost by the patient. If the second test is positive, she has been given every possible chance to continue her pregnancy.

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We have used this test in 16 patients presenting the symptoms of threatened abortion, viz., cramps and uterine bleeding, or spotting. In six of these patients we found that the abortion was threatening only, and prompt anti-abortive therapy produced a continuation of pregnancy. By the test ten patients were found to have either inevitable or missed abortions, and they were treated accordingly. In these patients the test was always repeated at least once in a period of 12 to 24 hours.

One of the big advantages of the male frog pregnancy test is the rapidity with which the test becomes negative after the abortion becomes inevitable. With the Ascheim-Zondek or the Schneider-Friedman tests, the persistence of the positive reaction does not necessarily imply that the embryo is still living, (5). The pregnancy reaction may persist 7–10 days after the termination of a pregnancy. In the male frog test it becomes negative within 10–12 hours, (6).

We believe that by the use of the male frog pregnancy test any physician, without the help of any laboratory test except that which he himself can perform, may make a differential diagnosis between threatened abortion, and inevitable or missed abortion, within a period of time varying between two and twenty-four hours.

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